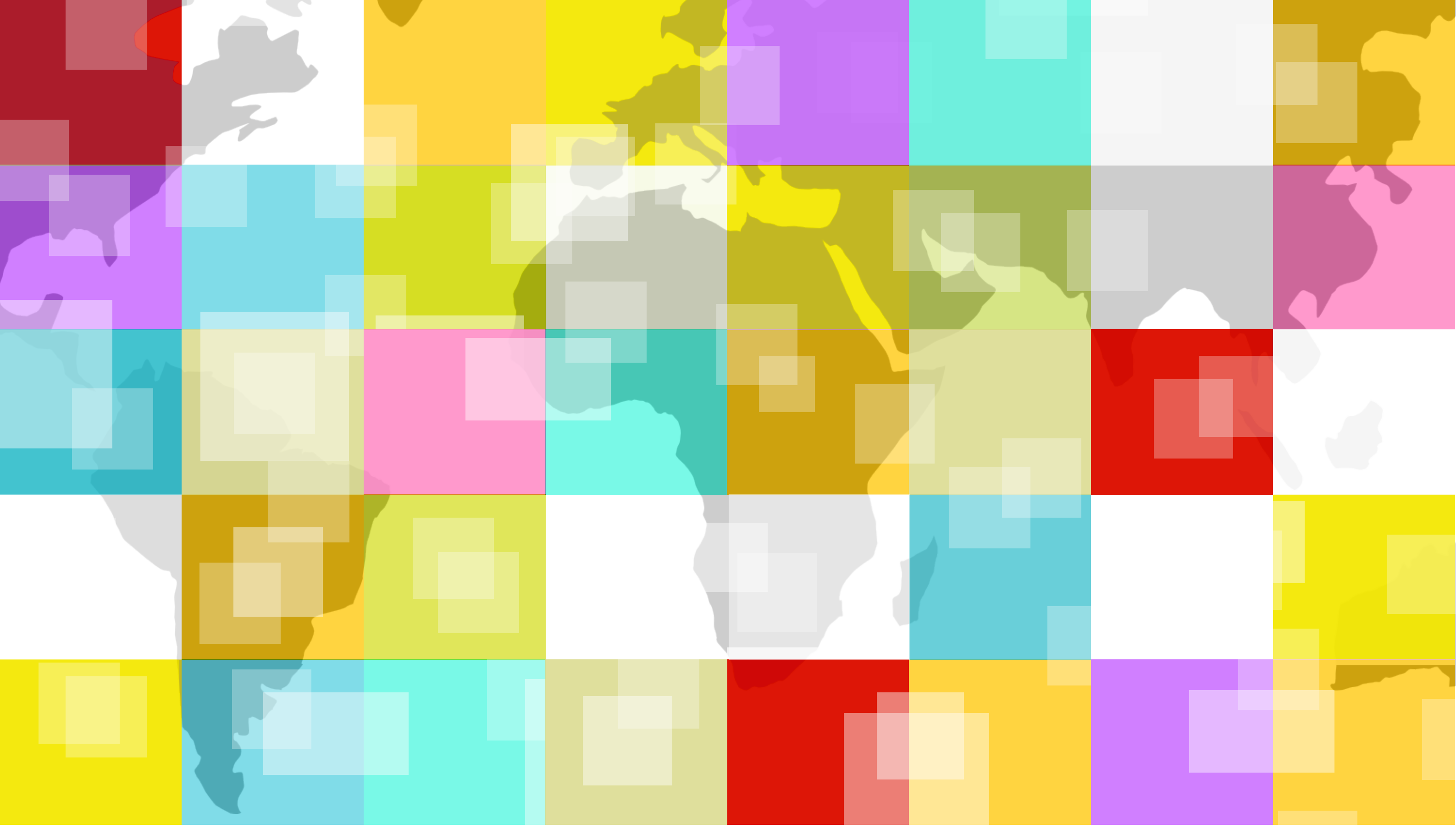

Science Literacy in Developing Countries
Landscape Survey

Summary Report

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Preface

This report is a summary of the findings that were presented in a slightly more extensive version to the co-funder Hardie Wren Development Initiatives (HWDI) in December 2016.

Acknowledgements

NIDA would like to extend thanks to all organisations, institutions, and individuals who responded to the initial announcement of the research; to those who participated in the debate and discussion on definitions of terms used to describe the fields of interactions between science and the public; and, to those who have provided, and continue to provide, recommendations of practical innovative initiatives.

Within NIDA, particular thanks are given to our country advisers and partners, to Rob Davies for his boundless energy and commitment, to Carol Usher who supported us all in her exemplary efficient and seemingly effortless manner and to Rebecca Bailey for her assistance in developing the case studies.

Finally, thanks are given to the Hardie Wren Development Initiatives (HWDI) for their contribution in co-financing.

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EXECUTIVE SUMMARY

Introduction

1 Discussions in Europe and North America often focus on science literacy topics such as genetically modified foods, antibiotic resistance, green energy etc. They almost always assume that people's essential basic needs are met and that they are free to make choices. The survey confirmed that for populations in the developing world the need is to address issues more immediate to survival and life, such as water and sanitation, AIDS and HIV, maternal and child health, education and food security.

Research Process

2 Extensive desk research was followed by a comprehensive consultation exercise. NIDA's global network was used as the initial base for engaging participation; for increased depth it was enhanced by working with leading partners in science. A wide variety of communication channels were used. Debate and discussion was stimulated around the issue of definitions. The process culminated by a call for recommendations of activities illustrating practical innovative initiatives that bore potential for adaptation or replication in different cultures and contexts.

What is Science Literacy?

3 A number of different terms are used to describe the fields of interactions between science and the public. The research included debate and discussion of those used most commonly, for example, Public Understanding of Science, Health Literacy, and Science Literacy. The report presents the consensus reached and also describes the expanding – and related - field of Citizen Science.

4 Recognition of the clear relationship between science literacy and health literacy to provide a more developed perspective is required. A redefined health literacy would include reference to the wide range of skills and competencies that need to be developed to seek out, comprehend, evaluate and use information, including abilities to understand scientific concepts and content in addition to health research.

This type of relationship between literacies leads to the concept of 'issue literacy', an essential pre-requisite for authentic multi-stakeholder and/or multisector interactions and essential to meeting the goals of sustainable development agenda of today.

5 Given the growing centrality of science and technology in modern societies, formal education should equip most people to be scientifically literate but for people who have not benefitted from this to date, the question is how can the knowledge gap be filled? Is it feasible to think in terms of equipping adults with a basic 'toolbox' of knowledge and skills about science and technology? The survey confirmed that opportunities for lifelong learning in informal settings are also required. These are more likely to be successful if these efforts are related to specific issues which are relevant to the everyday lives of individuals and communities in their own localities.

Science Literacy in Developing Countries

6 The majority of respondents recognised that broad access to scientific information is key for people to understand, participate and respond to the challenges that development poses. Additionally, it was noted that understanding of issues such as evolution, loss of biodiversity, implications of genetic research, global warming and many other topics is essential for personal involvement and that taking action on important issues requires science literacy.

7 Respondents emphasised the role that local content plays in preparing scientifically literate individuals and communities in developing countries. It was additionally recognised that many international interventions often assume use of English. However, science literacy efforts using oral communication, simple text, animation in local language have much greater involvement, engagement, and impact. Use of local language in local cultural context cannot be underestimated.

8 A wide range of sources from within the literature search, backed up by respondents and the illustrative case studies to this survey, indicate that science education, in both formal and informal settings, can make a significant contribution to both the understanding of science and the promotion of science literacy. However, expectations have not been met and well-trained and motivated teachers remain in short supply and curriculum reforms have often not been implemented as planned.

9 While it is broadly true that "wealthier is healthier", illiteracy may be a much stronger predictor of poor public health than low average income. This is illustrated by India, where research suggested that increasing literacy within a process of alleviating poverty has a greater impact on public health.

10 The Daejeon Declaration on Science Technology and Innovation (STI) Policies for the Global and Digital Age, emerging from the OECD Ministerial Meeting, Daejeon, 2015, stated a commitment to support STI to foster sustainable growth, job creation and enhanced well-being. The Sustainable Development Goals also recognised that science enlarges understanding of nature and society. Both these policy fora outlined provisions relevant for science literacy.

In practice, national policies, for example, that of China which has a firm plan to increase the public's scientific literacy, show greater potential for increasing scientific knowledge and relevant thinking ability to meet needs in emergencies, such as earthquakes, to build awareness and action, for example in reducing environmental degradation and to promote innovation and creativity towards scientific and technological advances.

Conclusions

11 The survey concluded that in the context of the developing world, new definitions of science literacy are required to ensure that public communication of science and technology addresses real needs.

12 Further work is required, globally, in describing, understanding and clarifying the relationships between issue literacies, 'multi-literacies' and their relationships with different types of literacy in order to achieve communication across the 'silos'.

13 The survey confirmed there is a strong need for improved science literacy in developing countries, where recognition and adoption of coherent policies and actions remains sporadic and lacking cohesion. This requires continued attention to strengthening the practical and theoretic basis for both advocacy and implementation.

14 There are numerous aspects of life in developing countries upon which science literacy could have a beneficial impact including: food security, food safety, disease prevention, maternal health, water management; safety and sanitation in urban environments; agriculture and rural development; diet and nutrition. Within these, the case was argued for new efforts to focus initially on three priority areas:

- climate Change;
- biodiversity, environmental degradation and conservation;
- maternal health, reproduction and birth practices.

Recommendations

15 Intensified cooperation between strategic organisations in the field such as the Inter Academies Partnership (IAP), the International Council for Science (ICSU), the Federation of Library and Information Professionals Working Group on Information Literacy (IFLAWGIL), the European Conference on Information Literacies (ECIL), FAO and WHO should be developed in order **to establish a clearer understanding of the relationship between the various basic and issue literacies** and **to identify strategies, cooperative programmes, projects and activities that will develop and utilise science literacy to better support meeting basic needs.**

16 Recommendations are also made for support to localised, well-structured and carefully evaluated pilot projects designed **to strengthen the evidence base and stimulate scaling up or adaptation of successful practices**.

17 Consideration should also be given to demonstrate the ways in which people can be attracted to improve their science literacy by **improving the service infrastructure supporting it**, for example by introducing science-related makerspaces and maker events in schools, libraries, museums and community venues.

18 The majority of participants with whom the research came into contact recommended (and asked) that **a Science Literacy network** be formed to facilitate sharing of experience, to map activities in order to reduce duplication of effort, to increase targeted gap-filling, to take a lead in bringing together key organisations and stakeholders to develop policies, to showcase activities and develop links to resources that bear potential to be adapted and replicated.

19 Establishment of **an annual award** to recognise outstanding achievement and/or innovation in a science literacy activity. The research was unable to find any existing award in the field and informal discussions during interviews confirmed that the presence of such an Award would have many benefits in enabling showcasing of innovative initiatives holding potential for adaptation and replication locally, within countries, within regions and perhaps globally.

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ACRONYMS

AAAS	American Association for the Advancement of Science
ASEAN	Association of Southeast Asian Nations
BIREME	Latin American and Caribbean Center on Health Sciences Information
CAST	China Association for Science and Technology
CILIP	Chartered Institute of Library and Information Professionals
CS	Citizen Science
CGIAR	Global Agricultural Research Partnership
CTA	Technical Centre for Agricultural and Rural Cooperation
ECOSOC	Economic and Social Council (of the United Nations)
ECIL	European Conference on Information Literacy
FAO	Food and Agriculture Organisation
GAPMIL	Global Alliance for Partnerships on Media and Information Literacy
HIFA	Health Information For All
HL	Health Literacy
IAP	InterAcademies Partnership
ICSU	International Council for Science
IFLA:WGIL	International Federation of Library Associations Working Group on Information Literacy
IL	Information Literacy
MIL	Media and Information Literacy
PUoS	Public Understanding of Science
SDG's	Sustainable Development Goals
SL	Science Literacy
STI	Science, Technology and Innovation
UN	United Nations
UNECA	United Nations Economic Commission for Africa
UNESCO	United Nations Educational, Scientific and Cultural Organization
WFP	World Food Programme
WHO	World Health Organisation

SECTION 1. INTRODUCTION

To function well in the 21st century a person anywhere in the world must possess a wide range of abilities and competencies, in essence many 'literacies'. These literacies - from being able to read simple notices in a newspaper to understanding information provided in many formats by an external source or service provider - are multiple, dynamic, and malleable. Some types of literacy may be designated 'issue literacies', such as those for science and health.

Almost fifteen years ago, the workshop Public Understanding of Research in Developing Countries[1] assessed that "In developing countries, modern science and technology offer hope for addressing the pressing needs of improved nutrition, public health, safety and shelter" but went on to say that "often when something seems obvious, it's a good idea to look more closely". The workshop concluded that new definitions of science literacy are required to ensure that public communication of science and technology addresses the real needs of people and societies in the developing world. This study has come to similar conclusions.

Discussions in Europe and North America often focus on science literacy topics such as genetically modified foods, antibiotic resistance, green energy etc. They almost always assume that people's essential basic needs are met and they are free to make choices. In contrast, for populations in the developing world the need is to address issues more immediate to survival and life, such as water and sanitation, AIDS and HIV, maternal and child health, education and food security. As the Cape Town workshop concluded "*The developed world has the luxury of detached interest in reliable knowledge about the natural world. In contrast, public understanding in the developing world must focus on knowledge upon which one can act immediately*".

Dr Elizabeth Rasekoala[2], chair of the Pan-African Solidarity Education Network, has long advocated for a more inclusive approach in the way science is portrayed, communicated and practised in Africa, suggesting that science must relinquish three current aspects to arrive at a win-win, give-and-take situation where science belongs to and benefits everyone:

- male dominance;
- Eurocentrism;
- the idea that it is the only answer to all humanity's problems.

She also stressed the importance of empowering young people around the world with the knowledge that every part of the world has contributed to the history of science. However, communicating cutting-edge science while respecting local cultures can be a difficult balancing act. In fact, more knowledge of science may lead to a polarisation of views about it, shaped by a multitude of factors, including the legal, ethical, and moral dimensions.

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[1] Report from Public Understanding of Research in Developing Countries, Cape Town, South Africa, December 2002

[2] https://theconversation.com/science-needs-to-start-speaking-to-peoples-everyday-lives-in-africa-67938

Communicating only the facts is likely to fall short. Expertise in the intricacies of science communication, its 'political aspects' diverse social settings and responses, can make a difference. Understanding and respecting audiences, a cardinal rule of effective and socially inclusive communication, usually involves mutually beneficial dialogue between scientists and communities, rather than a one-way, top-down flow of information. Engagement of interest entails relevance: a connection between science and everyday lives not centred on the promotion of science itself, but rather embedding it in society and facilitating participation.

Fine examples exist of science communication crossing cultural boundaries by bringing together current and traditional knowledge, for example in African children's storybooks about subjects such as the night sky, participative educational theatre about HIV prevention, science-art collaboration, the use of first languages and the inclusion of indigenous knowledge systems in areas such as drought-tolerant crops or new medicines.

In the context of science literacy in developing countries, other debates around the meaning of the 'literacies' are also very relevant. A basic definition of 'traditional literacy' is the ability to read and write. Arguments have also been advanced for its expansion to include the integration of listening, speaking, reading, writing, critical thinking, cultural knowledge and related skills.

People working within the field of information literacy propound a generic role not dissimilar to that of traditional literacy, as an underpinning factor in different types of issue literacy. Traditional literacy may be held likewise to underpin information literacy - or vice versa. The beginnings of a possible structure of literacies is suggested but not yet clear.

Health literacy, for example, has emerged as a concept that involves the bringing together of people from both the health and 'traditional' literacy fields, building on the idea that both health and literacy are critical resources for everyday living: our level of literacy directly affects our ability to not only act on health information but also to take more control of our health as individuals, families and communities.

The relationships between issue literacies can themselves be complex. Health literacy is seen by some as a subset of science literacy and literacy in technology is frequently associated with digital literacy. Similar complexities have arisen regarding the relationship between information literacy and media literacy, resulting in the composite notion of Media and Information Literacy (MIL), which itself has several distinct emphases. Specific issue literacies may spawn clearly-delineated sub-literacies e.g. maternal health literacy. A common thread may be that all issue literacies tend to involve social, cultural, emotional aspects that affect the way in which people engage with them.

Some thinking has tended toward a multiple literacies approach ('multi-literacies') in which the complementary nature of different types of literacy is established leading to collaboration. However, further work is needed in this direction to achieve such a clarification and to improve communication across 'silos'.

Issue literacy may be seen an essential pre-requisite for authentic multi-stakeholder and/or multisectoral interactions and partnerships. The gradual development of public knowledge about the HIV/AIDS epidemic and its role in informing activism, individual and collaborative action is held to be a strong example of this outcome.

Lancet editor-in-chief Richard Horton has recently argued for a holistic 'planetary health' as an approach, specifically linking health with other sustainability issues relevant to the whole of society such as education, adolescence, gender, justice, environment, human-caused changes to climate and other dimensions, speaking of a '*vision … for a planet that nourishes and sustains the diversity of life with which we coexist and on which we depend….the health of human civilization and the state of the natural systems on which it depends…. connect humanity's environmental impact on the planet with the survival of human civilization itself. being stewards for all the things that surround us*'[3].

In conclusion, while one question in our minds during this brief survey relates to the possible need for redefinition of science literacy in the context of developing world, there are other important issues including the need to address fragmentation of approaches and achieve more integrated approaches, to make dialogue more productive and to understand individual, complementary and laterally connected issues.

[3] Hornton, R *Keynote Address*, Duke Global Health Institute's 10th anniversary symposium, October 5th 2016

SECTION 2. THE RESEARCH PROCESS

The survey started in mid-September 2016, with an extensive literature search. The next stage was communication with relevant communities, stakeholders and individuals through email, listserv presence, Facebook, Twitter, Linkedin etc., followed by consultation through online fora, in workshops, through meetings and participation in conferences. The foundation was NIDA's global network, with a non-sector specific database of 7,311 institutions, networks, individuals working across the field of 'development' and a specialist database of 1,918 organisations and individuals with roles, programmes, and initiatives across all aspects of the Information and Knowledge for Development sector. A total of 76 countries were represented.

In the light of the subject matter, an especial effort was also made to involve the science community through networks and related bodies, for example, American Association for the Advancement of Science (AAAS), the InterAcademies Partnership (IAP), the International Council for Science (ICSU) family, national academies and science associations, and many other organisations, drawing on NIDA's access to science and practising scientists. The second community were those engaged in literacy in way or another: Global Alliance for Partnerships on Media and Information Literacy (GAPMIL), ECIL (European Conference on Information Literacy), CODE – Rewriting the Story for Global Literacy, IFLA WGIL (the International Federation of Library Associations and Institutions Information Literacy Section, CILIP (Chartered Institute of Library and Information Professionals): Information Literacy Group, the International Literacy Association and many individual programmes and activities. The third community were those engaged in international development – at international, regional, national, provincial and local level. This included the UN bodies, a wide range of multi-lateral and bi-lateral agencies, individual foundations, NGOs, networks, institutions and organisations and individuals within Asia, Africa and Latin America.

In total, over 1,500 responses were received to the communication process which involved at the outset sending out a brief introduction to aims and objectives, methodology and contact points, inviting involvement & participation and mentioning two specific 2 aspects: definitions; and requesting recommendations of innovative initiatives of good practice that were felt to bear potential for adaptation and replication.

SECTION 3. WHAT IS SCIENCE LITERACY?

3.1 Terms applied to public science activity in the developed world

A standard definition of science is: the intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment[4].

- A number of different terms are used to describe the fields of interactions between science and the public. During the initial stage of this study it was helpful to define those that are used most commonly, for example, Public Understanding of Science (PUoS), Health Literacy and Science Literacy. The expanding – and related - phenomenon of Citizen Science is also described below. In the process, a number of questions arose, including:
- What is the common thread or succinctly expressed relationship between these definitions of neighbouring fields?
- What are the key differentiators between them?
- What action is needed for them to interoperate beneficially?
- To what extent are they applicable in developing countries? What are the main constraints?

3.2 Science and the public

Among the relevant articles of the Daejeon Declaration on Science, Technology, and Innovation Policies for the Global and Digital Age[5] (2015) were that:

- public understanding of science, as well as public engagement and trust in key science and technology institutions, are necessary for society to fully exploit the opportunities created by innovation;
- policies are needed that support the positive transformational impact of digital technologies on research and innovation (and limit any anticipated risks), so as to promote "open science".

At least three terms are generally used to encompass relationships between science and the public: Public Appreciation of Science (PAS), Public Understanding of Science (PUoS) and Science (and Technology) in Society (STS).

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[4] https://en.oxforddictionaries.com/definition/science
[5] http://www.oecd.org/sti/daejeon-declaration-2015.htm

3.3 Public Appreciation of Science (PAS)

Science often holds an esteemed place amongst citizens and professionals and draws broad public support for government investment in scientific research. However, lack of knowledge of scientific concepts can mean that people do not fully appreciate the value scientific endeavour has for their own life and for society. Citizens and scientists often see science-related issues, such as the safety of GM foods, animal research and nuclear power through different sets of eyes. Many scientists believe that policy regulations on land use and clean air and water are not always guided by the best science.

PAS seeks to overcome this by getting science to be taken more seriously in the public sphere and overcoming anti-science sentiments in the media, on the Internet and among ordinary people. It seeks to engage people in and encourage enthusiasm and respect for science by seeing value or connections to themselves, thereby stimulating improvements in Science Literacy.

Public Understanding of Science (PUoS) addresses many aspects of the inter-relationships between science (including technology and medicine) and the public including: popular representations of science, scientific and para-scientific belief systems, science in schools, history of science, education of popular science, science and the media.

Whilst related to PAS, PUoS more frequently covers the methods used by the scientific community to present their scientific outputs to the public, for example by repackaging material into articles and books in popular formats, everyday language and illustrations; organising science fairs, establishing science centres and partnering in the organisation of museum exhibitions.

Science (and Technology) in Society (STS) is a relatively new interdisciplinary concept, referring to role of science and technology for the benefit of humanity. It emerges from the confluence of a variety of disciplines and sub-disciplines with an interest in viewing science and technology as socially embedded enterprises. When introduced into the European Union research framework in the early 2000s, the Science and Society programme included the following thematic areas: scientific advice; governance and reference systems; ethics in science; uncertainty, risk, and the precautionary principle; S&T - culture, young people, science education and careers; science awards; women & science.

3.4 Science Literacy (SL)

Science (or Scientific) Literacy (SL) itself commonly relates to the ability to think scientifically and to use scientific knowledge and processes to both understand the world around us and to participate in decisions that affect it.

The skill of being able to think scientifically about evidence - and the absence of it - in relation to claims that are made in the media and elsewhere is vital to daily life. Small amounts of accurate, relevant scientific information have the potential to transform individual, family and community abilities to shape their own world.

A scientifically literate person can be defined as someone who has the capacity to:

- understand, reflect upon and reason about scientific concepts, facts and processes relevant to environmental and social issues and required for personal decision making;
- ask, find, or determine answers to questions derived from curiosity about everyday experiences and natural phenomena;
- pose and evaluate arguments based on evidence and apply conclusions from such arguments appropriately;
- evaluate the quality of scientific information on the basis of its source and the methods used to generate it; interpret with understanding items about science in the popular media;
- identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed about daily life, the natural world and changes made to it through human activity;
- converse and communicate clearly and engage in reasoned discourse about science and technology.
- Given the growing centrality of science and technology in modern societies, it follows that formal education should equip most people in this way. Clearly, improved science education in formal schooling has an important role to play in creating favourable conditions for continuing science literacy. But for people who have not benefitted from this to date, the question is how can the knowledge gap be filled? Is it feasible to think in terms of equipping adults with a basic 'toolbox' of knowledge and skills about science and technology? Or is it likely to be more successful to relate these efforts to specific issues which are relevant to the everyday lives of individuals and communities in their own localities? In either case, opportunities for lifelong learning in informal settings are also needed.
- Equal opportunity is essential, to ensure that women and men participate in and benefit from advances equally as citizens and as contributors to the societies they live in. It is particularly urgent to boost the scientific literacy of women and girls. A majority of the world's 1 billion people living in poverty are women and children. Exclusion from science and technology and its potential benefits helps to perpetuate the vicious cycle in which they are trapped. Technological change, especially when it is designed to improve the quality of life, has often been more directed to the tasks that men perform. Empowering women to use technologies and understand science can benefit social and economic development as a whole.
- A report, *Science Culture: Where Canada Stands*[6], released by the Canadian Council of Academies in 2014, found that 42 per cent of Canadians have a basic level of scientific literacy necessary to understand media reports about science, putting Canada first among 35 countries with similar available data. A year earlier, in launching a national science literacy initiative, the government of China estimated that 3.6% of its population were scientifically literate.

[6] http://www.scienceadvice.ca/en/assessments/completed/science-culture.aspx

3.5 Health Literacy (HL)

Health literacy refers, broadly, to the ability of individuals to gain access to, understand and use information in ways which promote and maintain good health for themselves, their families and their communities. While different definitions are used and health literacy is an evolving concept, there is agreement that health literacy means more than simply being able to read pamphlets, make appointments, understand food labels or comply with prescribed actions from a doctor, although the ability to obtain, read, understand and use healthcare information to make appropriate health decisions and follow instructions for treatment is important.

Health Literacy also implies the degree to which people are able to access, understand, appraise and communicate information to engage with the demands of different health contexts in order to promote and maintain good health. This more developed perspective defines health literacy as the wide range of skills, and competencies that people develop over their lifetimes to seek out, comprehend, evaluate, and use health information to make informed choices, reduce health risks, and increase quality of life.

It includes the ability to understand scientific concepts, content, and health research; skills in spoken, written, and online communication; critical interpretation of mass media messages; navigating complex systems of health care and governance; and knowledge and use of community capital and resources, as well as using cultural and indigenous knowledge in health decision making. Health literacy is seen as a social determinant of health that offers a powerful opportunity to reduce inequities in health.

Specific types of health literacy include maternal health literacy, defined as: the cognitive and social skills that determine the motivation and ability of women to gain access to, understand, and use information in ways that promote and maintain their health and that of their children.

eHealth literacy is a term that describes the relatively modern concept of an individual's ability to search for, successfully access, comprehend, and appraise desired health information from electronic sources and to then use such information to attempt to address a particular health problem.

Society as a whole is responsible for improving health literacy, but most importantly the healthcare, public health professionals and public health systems. Where there are adequate levels of health literacy, that is where the population has sufficient knowledge and skills and where members of a community have the confidence to guide their own health, people are able to stay healthy, recover from illness and live with disease or disability.

Health literacy is important in addressing health inequities, since those at lower levels of health literacy are often the ones who live in poorer socio-economic communities. Not being aware of information relevant to improving their health, or how to access health resources creates higher levels of disadvantage. For some people, a lack of education and health literacy that would flow from education prevents empowerment at any time in their lives.

Weak health literacy skills are associated with riskier behaviour, poorer health, less self-management and more hospitalization and costs illustrated by recent repeated incidents of death and paralysing disease through cyanide poisoning caused by eating cassava in Nigeria[7]. Strengthening health literacy has been shown to build individual and community resilience, help address health inequities and improve health and well-being.

Health literacy is also not just a personal resource; higher levels of health literacy within populations yield social benefits, too, for example by mobilizing communities to address the social, economic and environmental determinants of health. This understanding, in part, fuels the growing calls to ensure that health literacy not be framed as the sole responsibility of individuals, but that equal attention be given to ensure that governments and health systems present clear, accurate, appropriate and accessible information for diverse audiences.

The scope of health literacy has also been seen as having three distinct 'levels'[8]:

- Functional literacy: skills that allow an individual, for example, to read consent forms, medicine labels, and health care information and to understand written and oral information given by physicians, nurses, pharmacists, or other health care professionals and to act on directions by taking medication correctly, adhering to self-care at home, and keeping appointment schedules.
- Conceptual literacy: the wide range of skills, and competencies that people develop over their lifetimes to seek out, comprehend, evaluate, and use health information and concepts to make informed choices, reduce health risks, and increase quality of life.
- Health literacy as empowerment: strengthening active citizenship for health by bringing together a commitment to citizenship with health promotion and prevention efforts and involving individuals in: understanding their rights as patients and their ability to navigate through the health care system; acting as an informed consumers about the health risks of products and services and about options in health care providers, and acting individually or collectively to improve health through the political system through voting, advocacy or membership of social movements.

Health literacy is important for population health because it can beneficially impact: health outcomes, rates of chronic disease, health care costs, health information demands; and health inequalities.

The United Nations ECOSOC Ministerial Declaration of 2009 provided a clear mandate for action: "We stress that health literacy is an important factor in ensuring significant health outcomes and in this regard, call for the development of appropriate action plans to promote health literacy."

[7] http://ipbo.vib-ugent.be/wp-content/uploads/2015/02/CCDN-News-20-December-2012.pdf
[8] http://www.who.int/healthpromotion/conferences/7gchp/Track1_Inner.pdf

Knowledge and understanding remain powerful tools in health promotion. Improving health literacy in populations provides the foundation on which citizens are enabled to play an active role in improving their own health, engage successfully with community action for health, and push governments to meet their responsibilities in addressing health and health equity. Meeting the health literacy needs of the most disadvantaged and marginalized societies will particularly accelerate progress in reducing inequities in health and beyond.

Health inequities are endemic to every region of the world, with rates of disease significantly higher amongst the poorest and most excluded groups. As a result, the populations least able to withstand the multidimensional costs of illness are also those most likely to endure them. This injustice is not mere coincidence – the poor are more likely to live, work, study and play in environments that are harmful to health. Health literacy efforts can uniquely reduce inequities in health and beyond, as the case studies in these pages illustrate.

Thirty years ago, the Ottawa Charter for Health Promotion recognized the need to enable people to increase control over and to improve their health and well-being by ensuring healthier, sustainable environments where people live, work, study and play. Social justice and equity were highlighted as core foundations for health, and there was agreement that health promotion is not simply the responsibility of the health sector. Subsequent WHO global health promotion conferences have reiterated these elements as key for health promotion.

The 2030 Agenda for Sustainable Development, the world's ambitious and universal "plan of action for people, planet and prosperity" offers a new opportunity to involve multiple stakeholders to ensure that all people can fulfil their potential – to live in health and with dignity and equality. While there is no specific target on health literacy within the Sustainable Development Goals (SDGs), efforts to raise health literacy will be crucial in whether the social, economic and environmental ambitions of the 2030 Agenda for Sustainable Development are fully realized. Increased health literacy gained through health education and various forms of communication, as well as actions taken through health systems and other policies, have the potential to support achievement of targets related to SDG 3 on health while advancing a wide range of other SDGs

The Shanghai Declaration on Promoting Health in the 2030 Agenda for Sustainable Development[9] includes a new focus on health literacy - a term encompassing the use of information and knowledge in healthcare, and particularly the application of health information and knowledge in education at all levels.

[9] http://www.who.int/healthpromotion/conferences/9gchp/shanghai-declaration.pdf?ua=1

Its commitments include to:

- recognize health literacy as a critical determinant of health and invest in its development;
- develop, implement and monitor intersectoral national and local strategies for strengthening health literacy in all populations and in all educational settings;
- increase citizens' control of their own health and its determinants, through harnessing the potential of digital technology;
- ensure that consumer environments support healthy choices through pricing policies, transparent information and clear labelling.

3.6 Citizen Science (CS)

By the mid-20th century, science was dominated by researchers employed by universities and government research laboratories. Subsequent calls for a democratization of science in the tradition of nature-loving amateurs like Descartes, Newton, Leibniz, Buffon, and Darwin, have led to the evolution of citizen science over the past four decades.

Citizen science is now usually defined as scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions. This type of public engagement in scientific research activities involves citizens actively contributing to science either with their intellectual effort or surrounding knowledge or with their tools and resources. It often involves public participation in data gathering or analysis of existing data and can be seen as both contributing to and benefitting from science literacy.

Large volunteer networks of non-scientists often allow scientists to accomplish tasks that would be too expensive or time consuming to accomplish through other means. Participants provide and interpret experimental data and facilities for researchers, raise new questions and co-create a new scientific culture.

In this process, volunteers acquire new learning and skills, and deeper understanding of the scientific work in an appealing way. Science-society-policy interactions are improved leading to a more democratic research, based on evidence-informed decision making and thereby supporting Science Literacy. Many citizen science projects serve education and outreach goals. These projects may be designed for a formal classroom environment or an informal education environment such as museums. Recent projects place more emphasis on scientifically sound practices and measurable goals for public education.

The use of citizen science networks often allows scientists to accomplish research objectives more feasibly than would otherwise be possible. Answering big science questions around climate change and the diversity of life requires lots of data which researchers cannot gather alone.

Typologies of the level of citizen participation in citizen science, range between the following:

- crowdsourcing: where the citizen acts as a sensor;
- distributed intelligence: where the citizen acts as a basic interpreter;
- participatory science: where citizens contribute to problem definition, data collection and data analysis.

Characteristic principles of a citizen science project include:

- actively involving citizens in scientific endeavour that generates new knowledge or understanding;
- having a genuine science outcome such as answering a research question or informing conservation action, management decisions or environmental policy;
- both the professional scientists and the citizen scientists benefit from taking part through publication of research outputs, learning opportunities, personal enjoyment, social benefits, or satisfaction in contributing to scientific evidence;
- citizen scientists receive feedback from the project: for example, how their data are being used and what the research, policy or societal outcomes are;
- project data and metadata are made publicly available and, where possible, results are published in an open access format;
- citizen scientists are acknowledged in project results and publications;
- programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact;
- project leaders take into consideration legal and ethical issues surrounding copyright, intellectual property, data sharing agreements, confidentiality, attribution, and the environmental impact of any activities.

Recent studies indicate that the largest impact of citizen science is in research on biology, conservation and ecology where it is utilized mainly as a methodology of collecting and classifying data. Citizen science networks are often involved in the observation of cyclic events of nature (phenology), such as effects of global warming on plant and animal life in different geographic areas. and in monitoring programs for natural resources. A large number of initiatives resources and significant support structures in the USA and interest in Europe[10], is now widening. A growing number of Citizen Science projects also take place in Africa, South America and elsewhere in the developing world.

Despite clear advantages, Citizen Science approaches have drawbacks related to, amongst other things, the reliability of data and statistical issues, which need to be acknowledged and remedied.

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[10] The action group "Citizen Science to promote creativity, scientific literacy, and innovation throughout Europe" will be launched mid-December 2016, financially supported by the program European Cooperation in Science and Technology (COST) http://www.ub.edu/web/ub/en/menu_eines/noticies/2016/09/064.html

Technology is credited as one of the main drivers of the recent explosion of Citizen Science activity, by increasing the options:

- the Internet has been a boon to citizen science, particularly through gamification, enabling citizen scientists to gather data which will be analysed by professional researchers;
- citizen scientists can build and operate their own instruments to gather data for their own experiments or as part of a larger project and learn how to investigate environmental concerns using inexpensive DIY techniques;
- video technology has enabled expanded citizen science;
- free and open source frameworks are common features of CS projects;
- mobile technology and personal devices have further boosted the opportunities for citizen science: in the last few years, expanding even more rapidly with the development of smartphones, allowing more information to be shared through digital media.

Participants create and run projects where volunteers help with image classification, transcription and geocoding. Armed with phones that have built-in GPS receivers, volunteers can readily provide geo-location information about species or situations in real time. In the future, more phones could be outfitted with smart sensors, which would let people measure and record environmental data, such as air-quality levels and temperature readings.

Alternative definitions of citizen science place more emphasis on science communication and scientific citizenship: in this context, CS is more closely related to PAS (see above), including the concept of scientists who are engaged in the democratic and policy processes and/or whose work is characterized by a sense of responsibility to serve the best interests of the wider community.

In this idea, CS projects aim to promote public engagement with the research, as well as with science in general. Collaboration in citizen science involves scientists and researchers working with the public. Community-based groups may generate ideas and engage with scientists for advice, leadership and programme coordination.

Evidence is increasingly produced to demonstrate strong economic worth and monetary value in scientific fields such as biodiversity. Ultimately, citizen science allows for more research to be accomplished globally and connects people in a worldwide environmental movement.

SECTION 4. SCIENCE LITERACY IN DEVELOPING COUNTRIES

'Science for many is such an alien issue, the preserve of school and the educated elite'[11].

Several debates shaping the post-2015 Development Agenda have recognised that science literacy at the citizen's level in developing and transitional countries is also essential for increasing the possibility of sustainability and for the protection and conservation of irreplaceable global resources.

Citizens in developing countries still have limited access to reliable and current scientific information in their native language and at their level of understanding (i.e., without technical jargon). Illiteracy remains widespread and images also remain important in communicating knowledge.

Broad access to scientific information is a key for people to understand, participate and respond to the challenges that development poses. Understanding of issues such as global warming, loss of biodiversity, evolution, implications of genetic research, and many other topics is essential for personal involvement. They affect everyone and the better they are understood, the better and more appropriate actions in response will be, whether these are activism in public causes or changes at the personal level. Taking action on many important issues requires science literacy. Traditional knowledge had to be often complemented by scientific knowledge from various sources in order to make meaningful connections.

Whereas industrialized nations have easy access to scientific information, access in developing countries has been marginal at best.

Traditionally, there were several reasons for this:

- there have been many more books and science papers published in English about issues of relevance to developing countries than in their native languages;
- many scientists in developing countries have had difficulties in trying to publish their research results in American, European or global-scope journals;
- Libraries in developing nations were not able to buy expensive scientific journals.

It has for long been argued[12] that industrialized nations can help improve science literacy in developing countries by:

- giving their institutions access to current scientific literature;
- translating scientific information from English to other languages;
- publishing papers by scientists from these countries;
- creating literary exchanges between scientists everywhere.

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[11] Quote from a Director of a National Library Service in Africa
[12] Improving Science Literacy and Conservation in Developing Countries
Carlos L. de la Rosa, 2000. http://www.actionbioscience.org/education/delarosa.html

Over the years, significant actions have been taken towards this end, including:

- personal relationships and exchanges between scientists and educators in developing countries
- literary exchanges between institutions and organizations
- information sharing and donations of books and journals
- subsidies for publication of key works in native languages at reasonable cost
- support for the preservation and use of indigenous knowledge.

The emergence of widespread access to the Internet, providing access to a vast range of resources and information relevant to understanding science, increasingly supported by translation tools, has impacted this situation, but digital skills and information navigation necessary to use these resources are not yet universal.

One result is that societies have struggle to keep up with the effects that accelerated development have on their environment. A society that is conscious of effects of actions upon natural balance is likely to be more effective in putting into practice the tenets of sustainable development.

Respondents emphasised the role that local content plays in preparing scientifically literate individuals and communities in developing countries. It was additionally recognised that many international interventions often assume use of English. However, respondents gave examples of science literacy efforts using oral communication, for example in the Nairobi's Kibera slum communities, simple text for flash cards and posters in the Pacific Islands, animation in local languages, for example the global programme of Scientific Animations Without Borders (SAWBO) transforms extension information on relevant topics such as agriculture, disease, and women's empowerment, into 2D, 2.5D and 3D animations, which are then voice overlaid into local languages to request, by a large team of volunteers (over 90 languages are involved at the time of writing this report). Another interesting example is that of Biofertilizers and Biofuels of ‘My Land, Colombia’, which uses a combination of traditional and scientific knowledge to identify, and promote through SL, efficient and relevant uses for by-products of coffee processing and sugar cane production for the community. Respondents felt that local content in local languages in the local cultural context gains much greater involvement, engagement, and impact.

4.1 Formal education

There has been an increasing understanding that teaching and learning good school science may produce extensive contributions to economic development. The importance of scientifically literate citizens and workers is likely to increase further as a result of the fast introduction of new technologies.

Valuable information is available in developing countries, several of which have attempted to implement significant science education reforms, ranging from the use of low-cost/no cost equipment to deliver hands-on science instruction to using extremely high technology-high cost methods of enhancing science instruction methods that, although more commonly used in industrial nations, are now spreading to wealthier developing countries. Work on Science Literacy Assessment is taking place, for example, in Indonesia[13].

A wide range of studies suggest that, whether in homogenous or language-diverse settings, science educators can make a significant contribution to both understanding science and promoting literacy. Educators, however, have not always had access to accurate, relevant and up-to-date information on most issues related to science. International bodies such as UNESCO have sought to remedy this for more than 50 years by supporting programmes to develop science education at secondary and higher education levels. As long ago as 1995, UNESCO recommended that by 2001 all countries should have in place appropriate structures and activities to foster scientific and technological literacy for all, seeing science literacy at the citizen's level in developing countries as essential for the sustainable development and for the protection and conservation of irreplaceable global resources.

Despite increased enrolments in science courses, expectations have often not been met. Well trained and motivated science teachers have remained in short supply in many countries and curriculum reforms have not been implemented as planned. Lack of resources, poor coordination and inadequate planning are identifiable causes.

4.2 Basic literacy

Pro-market policies for developing countries have long been based on the belief that increasing average income is key to improving public health and societal well-being. However, research on India[14] suggests that alleviating poverty and increasing literacy has a greater impact on public health and that while it is broadly true that "wealthier is healthier" illiteracy is a much stronger predictor of poor public health than low average income. A poor district can enjoy relatively good public health if it has a high literacy rate, acting as a base, enabling populations to understand medicine labelling, access healthcare, and engage with public health programmes, reporting ailments etc.

4.3 Access

A wide range of trusted points of potential and actual access to scientific knowledge exist, these include: information and science literacy programmes, including birthing centres, rural field stations, community and refugee service points, museums, science centres and public libraries.

The advent of electronic information, particularly the Internet and other means of global information access have transformed the ways in which people can obtain information. The capacity of broadcast media to promote understanding of science remains somewhat under-exploited.

[13] http://www.ijese.net/makale/736
[14] http://www.cam.ac.uk/research/news/literacy-not-income-key-to-improving-public-health-in-india

4.4 Gender

A majority of the world's 1 billion people living in poverty are women and children. Exclusion from science and technology and its potential benefits helps to perpetuate the vicious cycle in which they are trapped. Discrimination against women in science exists in societies where there is a strong history of patriarchy. Empowering women to use technologies and understand science can benefit social and economic development as a whole.

An array of initiatives has emerged across the development spectrum seeking to empower girls, in response to both concerns about inequitable progress and faith in the social dividends of investing in girls and women. The development community focussed on girls as the best catalysts for social change for some years. It has, however, been argued that this approach also assumes that girls have - or can be given - the power to transform their circumstances, and ignores the vast structural impediments to change, over which girls themselves have little influence. It can also create a narrow and idealised model of who 'girls' are, what they want and what challenges they face including reducing teenage pregnancy, birth practices, reproduction and maternal health, economic empowerment and violence prevention.

Both development agencies and community programmes drew attention to ongoing analysis of the effectiveness of whether investment in girl's and women's programmes is the most effective catalysts for change or whether approaches via family and community activities are more long-lasting and successful. Whichever model is utilised it appears probable that improvements in health/science literacy have a role to play in meeting more equitable progress.

Consulting ordinary citizens on what science should be done and how it should be applied could especially benefit women, since they are rarely involved in research projects and rarely get a chance to voice their needs.

4.5 International policies

Noting that the Daejeon Declaration on Science, Technology, and Innovation (STI) Policies for the Global and Digital Age[15] emerging from the OECD Ministerial Meeting Daejeon 2015, World Science Forum stated a commitment to support science, technology and innovation to foster sustainable economic growth, job creation and enhanced wellbeing. It noted that achieving these goals will require adequate investment, and policy and regulatory environments that support strong and well-connected global science and innovation systems, and which also enable creativity and innovation throughout the economy and society, recognising that changes in science and innovation systems, influenced by digitisation and globalisation, require that national and international policy agendas and instruments be updated.

[15] http://www.oecd.org/sti/daejeon-declaration-2015.htm

This was based on a vision that STI improve the quality of life for all citizens as they increase employment, productivity and economic growth in a sustainable manner over the long term; provide new opportunities for investment, both for start-ups and established firms, in developed and developing countries; and are essential to meeting global and societal challenges, such as environmental sustainability, climate change, developing new sources of energy, food security and healthy ageing, hence achieving the Sustainable Development Goals agreed by the United Nations[16]. Moreover, science enlarges our understanding of nature and society.

Among provisions relevant to Science Literacy:

- In addition to agreeing that STI policies are being revolutionised by the rapid evolution of digital technologies, producing an increased reliance on 'open science', the Declaration highlighted the opening of new avenues for public engagement and participation in science and innovation ('citizen science'); research co-operation between businesses and the public sector and their contribution to the transformation of how innovation occurs ('open innovation').
- It was agreed that science, technology and innovation have become more global, with emerging countries becoming major actors and many issues reaching global scale, like climate change, food security, neglected diseases, global health issues (e.g. dementia) and pandemics (as illustrated in the recent Ebola outbreak) and recognised that science is increasingly important to inform policies and decision making across a broad range of areas, from long-term environmental and public welfare issues to emergency disease outbreaks and natural disasters.
- Public understanding of science, as well as public engagement and trust in key science and technology institutions, are seen as necessary for society to fully exploit the opportunities created by innovation.
- The scientific and technological advances required to address new health challenges would be facilitated by collaboration among governments, academia, patients, and industry throughout the R&D and regulatory processes (for instance through data sharing, citizen science, crowdsourcing, virtual platforms for encouraging peer-to-peer networks and other collaborative research).

The Sustainable Development Goals likewise present an opportunity to give citizens a say in shaping local science activity and the innovations that follow from it. The explosion of science initiatives now taking place across the continent in the wake of the SDGs means local people need a say in what research is being done, helping ensure Africa's research agenda supports wellbeing and healthy growth on the continent[17].

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[16] http://www.un.org/sustainabledevelopment/sustainable-development-goals/

[17] http://www.scidev.net/global/sdgs/news/sdgs-citizen-science-africa.html

4.6 The link to innovation

It is elsewhere argued that developing countries are the most efficient innovators[18], achieving results in areas such as scientific research, infrastructure and technology production with relatively low inputs. By measuring the ratio between innovation inputs and outputs on these indicators, the index found that eight developing nations - Mali, Guinea, Swaziland, Indonesia, Nigeria, Kuwait, Costa Rica and Venezuela - are among the top ten most efficient innovators. However, an "innovation divide" persists because overall innovation levels still lag well behind those of richer nations.

The fact that the list of the top 25 innovators remains unchanged from the previous year and solely comprises high-income countries shows that developing nations still face serious obstacles to progress, the report says. One of the biggest brakes on progress in low and middle-income countries is identified as lack of collaboration between the research community and the private sector.

4.7 National policies

In 2013, China announced a firm plan to increase the public's scientific literacy as part of its objective for knowledge-intensive services to contribute to 20 percent of GDP by 2020. Among measures to be taken were greater efforts in the education, publicity and popularization of science, intending to raise the proportion of scientifically-literate citizens to 10 percent by 2020. A 2015 survey by the China Association for Science and Technology (CAST) revealed that the proportion of scientifically-literate citizens has almost doubled from 3.27 percent in 2010 to 6.2 percent last year, higher in major cities (e.g. Shanghai 18.7%), similar to levels in the U.S. and Europe at the turn of the century.

The central authorities also issued national standards to measure Chinese citizens' scientific understanding involving not only scientific knowledge but also relevant thinking ability: 'for example, when an earthquake or an emergency happens, people need to have the basic ability to save themselves or others'. By the end of 2014, China had more than 1,100 science and technology museums.

However, in a country that has an online population of 710 million, the Internet is now the preferred channel for people to gain science information. The CAST survey found that over 53 percent of Chinese people obtain scientific knowledge online and for those with a better scientific understanding it rises to over 91 percent. Science-related websites, digital museums, and digital libraries are all seen as playing a part in the campaign and a need to draw in more private funding is identified. The plan targets youngsters, farmers, migrant workers and public servants as key groups targeted in the science promotion campaign, with changes called for in the science education of young Chinese. A national policy to promote mass innovation and creativity through the wide introduction of makerspaces was also announced in 2015.

[18] http://www.scidev.net/global/innovation/news/developing-nations-hailed-as-most-efficient-innovators.html

4.8 Science in developing countries

There are by now, a substantial number of Citizen Science projects in Africa, South America and elsewhere. The involvement of volunteers in supporting professional scientists to collect data stretches from Congo, Kenya, Nigeria, South Africa, Tanzania to Argentina, Brazil, Chile, Colombia and Peru and embraces projects on astronomy, water security, climate change impacts, flora and fauna species documentation and biodiversity in general, logging activity, crop disease, health epidemiology and testing new cancer therapies.

The SDG offer a chance to shape science agenda to meet the needs of people and can be a beacon for innovation in the way research programmes are designed to include the people who are meant to benefit. The goals have created a renewed interest in research among the development community, which may make it easier for researchers in developing countries to connect with a population already interested in science.

More and more Africans are becoming citizen scientists – and the benefits are huge both for them as individuals and for science on the continent. Gathering environmental data is a key focus of African citizen science. In South Africa, Kenya and Uganda, for instance, volunteers monitor and record data on everything from mangrove ecosystems to beach erosion; along with a variety of animals and insects like sea turtles, bats, owls, frogs, lizards and butterflies.

The contribution of citizen science goes beyond gathering or unravelling data. Enthusiastic volunteers also bring their computer equipment and technological skills to assist with number crunching and data analysis. They can fill in knowledge gaps by providing scientists with extra hands, eyes, computers, cameras, smartphones and vehicles.

Nevertheless there are a number of criticisms within CS, revolving around the quality of data collected by non-experts and the potential for conflicts of interest – ordinary people who are opposed to fracking, for instance, might get involved in projects just to gather information that supports their stance.

Inclusivity is also a particular challenge when it comes to citizen science projects. It can be difficult to involve people who don't have their own transport or access to smartphones, computers and internet; or where literacy rates are low. Some initiatives in Africa are getting creative to address these problems. The Extreme Citizen Science research group in the Democratic Republic of Congo is working with communities toward this end.

Despite its limitations, citizen science has an important place in Africa. It is a way of driving public engagement; of creating linkages and dialogue between science and society. It can inspire people to take an interest in science and enthuse young people about careers in science. It also helps make science a part of everyday life and represents a vital step towards democratising science.

SECTION 5. SCIENCE LITERACY: MAJOR AREAS OF IMPACT OPPORTUNITY

The survey confirmed that there are numerous aspects of life in developing countries upon which science literacy could have a beneficial impact including: food security, food safety, disease prevention, maternal health, water management; safety and sanitation in urban environments; agriculture and rural development; diet and nutrition and others.

As for many initiatives, evidence of the impact of science literacy activities on individuals and society is needed to encourage adoption of good practice elsewhere. Several areas of considerable promise have emerged.

The case is argued here for efforts to focus initially on three main areas where the research survey identified that the need for science literacy is especially pressing and where short-to-medium term benefits may be achievable.

The three areas are:

- climate change;
- biodiversity, environmental degradation and conservation;
- maternal health, reproduction and birth practices.

5.1 Climate change

"Living with climate change not only suggests the need for improved scientific literacy, it also suggests the need for improved literacy – better understanding of how language and communication works in public life, the interplay between language and action in the world."
Mike Hulme, King's College London, October 2016

Climate science literacy has been identified as an individual sub-literacy within the science literacy issue, defined as 'an understanding of your influence on climate and climate's influence on you and society'[19]. Within this, a climate-literate person is seen to be someone who:

- understands the essential principles of Earth's climate system;
- knows how to assess scientifically credible information about climate;
- communicates about climate and climate change in a meaningful way; and,
- is able to make informed and responsible decisions with regard to actions that may affect climate.

[19] https://www.climate.gov/teaching/essential-principles-climate-literacy/what-climate-science-literacy

This rich topic can be approached at many levels, from comparing the daily weather with long-term records to exploring abstract representations of climate in computer models to examining how climate change impacts human and ecosystem health. Learners of all ages can use data from their own experiments, data collected by satellites and other observation systems, or records from a range of physical, chemical, biological, geographical, social, economic, and historical sources to explore the impacts of climate and potential adaptation and mitigation strategies.

The Climate Education and Literacy Initiative launched by the White House Office of Science & Technology Policy (OSTP) in 2014 is an important example of strategic efforts in this direction[20]. Guidance on teaching climate literacy has also been produced[21].

Climate change poses a serious threat to development and poverty reduction in the poorest and most vulnerable regions of the world. The Intergovernmental Panel on Climate Change (IPCC) concluded a decade ago that human activity (primarily related to fossil fuel consumption) is largely responsible.

While climate change will affect everyone, it is expected to have a disproportionate effect on those living in poverty in developing countries, affecting aspects such as water resources, agriculture and forestry, food security, human health, Infrastructure (e.g. transport), settlements: displacement of inhabitants and loss of livelihood, coastal management, industry and energy, disaster response and recovery plans. Africa, Asia, Latin America and the Small Island States have all been identified as regions of concern.

This is compounded by the fact that developing countries are often less able to cope with adverse climate impacts such as changes in rainfall patterns, increased frequency and severity of floods, droughts, storms and heatwaves, changes in growing seasons, water quality and quantity, sea level rise and glacial melt. Action is required to build capacity to adapt or to mitigate climate change e.g. by introducing new crop varieties resistant to the effects of drought and to build on traditional coping mechanisms, indicating a need for increased awareness and climate science literacy.

'The Paris Agreement (COP21) and the United Nations Sustainable Development Goals (SDGs) require a wide-ranging membership of peoples, a global vision of the future, leading to a profound transformation of attitudes and behaviours in decades to come. Changes of such depth, marked by urgency and the future of today's youth, cannot be achieved without substantial transformations in formal education, alongside informal education, other aspects of citizens' information. This need is structurally recognized by the Article 12 of the Paris Agreement, following Art.83 of the UNFCC Framework Convention'[22].

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[20] https://www.whitehouse.gov/sites/default/files/microsites/ostp/climateed-dec-3-2014.pdf
[21] http://cleanet.org/clean/literacy/climate/index.html
[22] Seminar '' Education and Climate '' Friday, November 11th 2016- Training and National Meetings Center (CFRN), - Rabat. Morocco. http://www.interacademies.net/File.aspx?id=31050

5.2 Biodiversity, environmental degradation and conservation

Research shows that 10% of the world's wilderness has vanished in the past two decades involving large-scale losses of pristine landscapes, particularly in South America and Africa. Wild areas are often ignored in international conservation agreements, despite their ecological and cultural value.

Most of these untouched spaces are found in North America, north Asia, north Africa and Australia. They are often home to indigenous peoples as well as endangered plants and animals. About 20% of the world's land area is classed as wilderness. By this, scientists mean landscapes free of large-scale human disturbances such as housing, development and industry.

In Brazil, The Information System on Brazilian Biodiversity (SiBBr)[23] was launched in 2014 "aiming to encourage and facilitate the publication, integration, access and use of information about the biodiversity of the country. Its approach is now extended to incorporate citizen science. Projects cover marine megafauna, crop diseases and the genetic riches of soil from the perspective of antibiotics development.

Whilst International policy mechanisms are required to recognise the actions needed – such as increased investment and rewilding, to maintain wilderness areas before much more is lost, widespread science literacy among citizens is required to enhance diagnosis and implementation. There are increasing opportunities for action in this respect.

5.3 Maternal health, reproduction and birth practices

Maternal health literacy has been defined as: the cognitive and social skills that determine the motivation and ability of women to gain access to, understand, and use information in ways that promote and maintain their health and that of their children. Specifically, it investigates the feasibility of using the concept of health literacy to guide the content and process of antenatal support activities.

Women today are having half as many children as their mothers and grandmothers. The global average is now down to 2.5 children per woman and continues to fall. However, this figure is not accurate for women in countries where they have little control over their reproductive wellbeing.

Worldwide, approximately 529,000 women die during childbirth or from complications during pregnancy each year – one woman dies every 90 seconds – and millions more are left with life-altering disabilities. In some countries, one in seven women dies in pregnancy or childbirth. Approximately 90 percent of these deaths occur in developing countries. The maternal death rate in these developing regions is approximately 300 times higher than those in developed countries.

[23] https://www.rnp.br/en/noticias/sibbr-completa-ano-seis-milhoes-registros

The risk of a woman dying in pregnancy and childbirth depends on the number of pregnancies she has in her lifetime - the higher the number of pregnancies, the greater the risk of pregnancy-related death. The differences in the maternal mortality rates between rich and poor countries, according to the World Health Organization, are the health indicator of the disparity between the two. The direct causes of maternal deaths are haemorrhage, infection, sepsis, eclampsia, obstructed labour, hypertensive disorders in pregnancy, and complications of unsafe abortion.

Successive pregnancies - one too soon after another - does not give the mother adequate time to recover after losing nutrients such as iron and folate due to pregnancy and breastfeeding leading to maternal depletion syndrome. Back-to-back pregnancies can deplete the mother's essential nutrients, putting her at higher risk for anaemia and other complications such as uterine rupture, which in turn puts babies at risk of low birth weight and preterm birth. In Niger, a woman gives birth to an average of nearly eight children. Uganda, Mali and Somalia are close behind, with an average of six to seven children per woman. Each pregnancy increases the risk of complications and death.

For every woman who dies, another 20 suffer illness or injury. Birth-related disabilities that affect many more women go untreated, like injuries to pelvic muscles, organs or the spinal cord. Another risk to expectant women is malaria. It can lead to anaemia, which increases the risk for maternal and infant mortality and developmental problems for babies. Nutritional deficiencies contribute to low birth weight and birth defects as well. HIV infection remains a continuing threat.

At least 20% of the burden of disease in children below the age of 5 is related to poor maternal health and nutrition, as well as quality of care at delivery and during the new-born period. And yearly 8 million babies die before or during delivery or in the first week of life. Further, many children are left motherless each year. These children are 10 times more likely to die within two years of their mothers' death.

UNICEF has identified the root cause as lying in women's disadvantaged position in many countries and cultures and in the lack of attention to, and accountability for, women's rights. Education and health literacy are pivotal to saving the lives of mothers and their new-borns and improving maternal and neonatal health than simply medical intervention.

The ability of women to command resources and make independent decisions about their fertility, their health and healthcare also has an impact on maternal mortality. Where women and girls are afforded a low status in society their health needs are often neglected. Additionally, lack of education and understanding around health-related issues can contribute to delays in seeking care when it is needed or to life-threatening pregnancy complications being inappropriately managed.

In rural Africa and elsewhere, women still have little to no control over their reproductive health, although they are well aware of the effects of numerous pregnancies. They also have multiple pregnancies because many of their children die due to new-born complications and childhood diseases, even though they may know they are at risk.

According to the World Health Organization (WHO), the first step in reducing maternal deaths is ensuring that women have access to family planning and safe abortion, which can reduce unwanted pregnancies and women resorting to unsafe abortions. However, in many cases, although they would like to limit family size, they don't have access to effective contraception that is affordable and acceptable.

Most maternal deaths are avoidable, as the healthcare solutions to prevent or manage complications are well known. Since complications are not predictable, all women need care from skilled health professionals, especially at birth, when rapid treatment can make the difference between life and death. For instance, severe bleeding after birth can kill even a healthy woman within two hours if she is unattended. About 62 percent of women in developing countries receive assistance from a skilled health worker when giving birth, which means that 45 million women give birth at home without assistance.

In some countries, traditional birth assistants also advise women on the use of traditional medicine, for example, to widen the birth canal and to precipitate labour. If something goes wrong during labour, they rely on traditional beliefs or witchcraft to explain the mishap and may expect the woman in labour to confess her purported 'bad' behaviour. They lack understanding of the causes of obstetric complications during childbirth, and have inadequate knowledge of the appropriate management of labour. Some traditional birth assistants are, however, in favour of providing support to labouring women in maternity units and learning about childbirth care from midwives, providing an opportunity to ensure that care during childbirth is clinically safe and culturally sensitive.

Clean birth practices can prevent sepsis, one of the leading causes of both maternal and new-born mortality. Evidence suggests that clean birth kits (CBKs) in countries such as Pakistan, as part of package that includes education, are associated with a reduction in new-born mortality, omphalitis, and puerperal sepsis. However, questions remain about how best to approach the introduction of CBKs in each country.

In the field of birth and reproductive health, there is evidence that women (and some men) are keen to understand more about their bodies and what's happening. Knowledge varies between some women knowing nothing at all about eating well, menstrual cycles, contraception and pregnancy to others having a good understanding of how drinking more water might make them feel stronger and how they get pregnant. Illiteracy is widespread so that tools such as images, oral interactions, simulations and games are important in communicating knowledge. Engaging local birth attendants who are known and respected in the community is often most effective.

Research shows the single most important intervention for safe motherhood is to make sure that a trained provider with midwifery skills is present at every birth, that transport is available to referral services, and that quality emergency obstetric care is available. Homebirth and out-of-hospital birth centres have been proven to have as safe or safer, outcomes than hospitals for normal deliveries. The important factor in whether childbirth will be safe or unsafe for a woman is three-fold: the overall health of the woman, her place in society, and the presence of a skilled birth attendant.

Part of the problem is that there is a worldwide shortage of midwives: only 60% of the women in the world have a midwife, or doctor or nurse with midwifery skills to assist at their childbirths. As women and midwives gain more autonomy, they move to humanize birth, understanding that the woman giving birth is a human being, not a machine and not just a container for making babies.

At the same time, for those women with access to a hospital, in some countries elective C-sections for hospital births have become commonplace. A variety of factors influence this. The convenience of performing a 60-minute caesarean procedure versus attending to a long labour and delivery may lead many doctors to see the time saved as of high importance. Elsewhere, the doctor-patient relationship means that women receive nearly all of their information about childbirth from their doctor, rather than from prenatal classes or activities.

Helping governments provide a quality primary school education also benefits maternal and infant health – particularly education for girls. Educating girls for six years or more drastically and consistently improves their prenatal care, postnatal care and childbirth survival rates. Educating mothers also greatly cuts the death rate of children under five. An educated mother is more likely to send her children to school.

Despite recommendations supporting optimal breastfeeding**,** the number of women practicing exclusive breastfeeding (EBF) remains low, and few interventions have demonstrated implementation and impact at scale. Initiatives such as Alive & Thrive (A&T)[24], supported by the Bill and Melinda Gates Foundation and the governments of Canada and Ireland, aims to save lives, prevent illness, and ensure healthy growth and development through optimal maternal nutrition, breastfeeding and child feeding practices. Alive & Thrive has developed a four-component approach to guide its work in large-scale infant and young child feeding (IYCF) programme, including: advocacy, interpersonal communication (IPC) and community mobilization, mass communication, and strategic use of data. Presently active in Bangladesh, Burkina Faso, Ethiopia, India, Nigeria, Southeast Asia (Cambodia, Indonesia, Lao PDR, Myanmar, Thailand, Timor-Leste, Vietnam, Philippines).

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[24] http://aliveandthrive.org/

SECTION 6. CONCLUSIONS AND RECOMMENDATIONS

This initial review of the science literacy 'landscape' led to the conclusion that there is a strong need for improved science literacy in developing countries, where recognition and adoption of coherent policies and actions remains sporadic and lacking cohesion. This requires continued attention to strengthening the practical and theoretic basis for both advocacy and implementation.

Taking into consideration the evidence and recommendations gathered during this review three priority areas where the need for science literacy is especially pressing remain as described in Section 5 above:

- climate change;
- biodiversity, environmental degradation and conservation;
- maternal health, reproduction and birth practices.

Suitable activities may take a number of forms. We recommend consideration be given to support for the following:

1 One or more localised, well-structured and carefully evaluated **pilot projects** in aspects of maternal and reproductive health and birth practices in poor rural and urban settings. A number of possible locations have been identified including: Kerala (India) and Vietnam (where a further, more holistic approach to women's and family well-being is foreseen). **Pilot projects** in the fields of climate change and biodiversity, environmental degradation and conservations should also be encouraged. All pilots should be designed to strengthen the evidence base and stimulate scaling up or adaptation of successful practices, including the preparation of localised training and content resources.

2 Projects and activities to demonstrate ways in which people can be attracted to improve their science literacy by improving the **service infrastructure** supporting it, for example by introducing science-oriented makerspaces and maker events in schools, libraries, museums and community venues.

3 Service-level and technical activities designed to extend and standardise the basis for **citizen science** activities, building on their success to date, so that a more permanent human resource is engaged in many more localities in developing countries in support of climate change awareness, biodiversity and environmental conservation and other science-related issues. The extension of citizen science to aspects of maternal health and birth/reproduction practices could represent an area of activity at once challenging and beneficial to evidence gathering.

4 Intensified cooperative work between strategic organisations in the field such as: the InterAcademies Partnership (IAP), the International Council for Science (ICSU), the Federation of Library and Information Professionals Working Group on Information Literacy (IFLA:WGIL), the European Conference on Information Literacies (ECIL), FAO and WHO designed **to establish a clearer understanding of the relationship between the various basic and issue literacies**, as a way of coordinating and easing their implementation and support in practice, possibly defining and moving towards a ‘multiliteracies’ approach, capable of being adapted to the amelioration of any issue with a scientific basis. Such approaches are likely to benefit from working closely with people who are already working in science communication.

5 The majority of participants with whom the research came into contact recommended (and asked) that **a Science Literacy network** be formed to facilitate sharing of experience, to map activities in order to reduce duplication of effort, to increase targeted gap-filling, to take a lead in bringing together key organisations and stakeholders to develop policies, to showcase good practice and develop links to resources that bear potential to be adapted and replicated. Developing country partners would know to whom they could turn for advice, resources, partnership and co-funding; the funding community at large would be able to get to know who is doing what where, what works, what does not; the community at large and beyond would know where resources and materials may already be developed, where are the large gaps ...in other words a network with a clearing-house function.

6 Establishment of **an annual award** to recognise outstanding achievement and/or innovation in a science literacy activity. The research was unable to find any existing award in the field and informal discussions during interviews confirmed that the presence of such an Award would have many benefits in enabling showcasing of innovative initiatives holding potential for adaptation and replication locally, within countries, within regions and perhaps globally.

CASE STUDIES

The final stage in the landscape survey was to collect examples of recent or ongoing practical innovative initiatives that have been proven to meet their objectives. Actions which had the potential to be adapted to a range of different cultures & contexts were of particular interest.

In line with the Terms of Reference for the survey, five were initially invited to prepare case studies to illustrate the landscape survey**.** However, given the level of response it is planned that over the next 3-4 months the following work will continue and the following will be included as selected examples:

Health - Medical

e-Bug - Educational resources on hygiene and infection for classroom and home use. http://www.e-bug.eu.html/ and http://www.nida-net.org/en/activites/information-literacy/science-literacy/innovative-initiatives-scienceliteracy/e-bug/

CASA - Communication training with medics, patients associations and patients in HIV and AIDS http://www.casaproject.info/team-casa/ and http://www.nida-net.org/en/activites/information-literacy/science-literacy/innovative-initiatives-scienceliteracy/CASA-project/

Scientific Animations Without Borders (SAWBO) - Training, research and creation of educational materials for Agriculture, health, women's education.
http://sawbo-animations.org/home/
and http://www.nida-net.org/en/activites/information-literacy/science-literacy/innovative-initiatives-scienceliteracy/sawbo/

Ebola Paul Richards, Wangingen: positive ebola
http://africanarguments.org/2016/05/19/how-black-bin-bags-and-common-sense-helped-end-ebola-and-what-we-can-learn-from-it/

Science

Pueblo*Science* - Science literacy through training teachers – Philippines & adapted to Guyana and also international summer schools – biochemistry, chemistry etc.
http://puebloscience.org/

Unizulu - Science educators and learners in KwaZulu-Natal schools
http://unizulusc.org/index.php/home

Zoouniverse https://www.zooniverse.org/projects:

alternative: http://earthjournalism.net/projects/citizen-science-sensors

Environment

Namib Desert Environmental Education Trust (NaDEET) - Protecting Namibia's environment by educating people to live a sustainable lifestyle.
http://www.nadeet.org/ and http://www.nida-net.org/en/activites/information-literacy/science-literacy/innovative-initiatives-scienceliteracy/NaDeet/

Kyrgyz Mountains Environmental Education and Citizen Science - A pilot project/research CAMP Alatoo Public Foundation & University of Central Asia http://camp.kg/en/ and http://www.nida-net.org/en/activites/information-literacy/science-literacy/innovative-initiatives-scienceliteracy/NaDeet/

'**Biofertilizers and Biofuels of 'My Land', Colombia'**
http://agrocombustiblesveredales.fresnodigital.info/

Climate Change

La Fondation La main à la pâte - The Foundation *La main à la pâte* is a foundation for scientific cooperation founded in 2011 by the Académie des Sciences, the École Normale Supérieure (Paris) and the École Normale Supérieure of Lyon. The Foundation's activities are carried out within France and internationally, providing assistance and professional development designed to help implement **inquiry-based** learning.
http://www.fondation-lamap.org/

HAGAMOS "¡Hagamos un MILAGRO por el aire!" ("Let's make a miracle for the air!")
http://www.mce2.org/en/outreach/hagamos

Feeding and Nutrition/Maternal Health

alive&thrive - Advocacy, education, program implementation, and knowledge partnerships around infant and young child feeding (IYCF) and maternal nutrition.
http://aliveandthrive.org/ and http://www.nida-net.org/en/activites/information-literacy/science-literacy/innovative-initiatives-scienceliteracy/alive-thrive/

The eHealth pioneers of Laos – Using mobile phones and SD cards to disseminate health message . e.g. https://blogs.unicef.org/east-asia-pacific/the-laos-e-health-pioneers/
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Canadian Science Week – http://scienceliteracy.ca/ and partners from http://scienceliteracy.ca/partners/

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Carnegie Corporation of New York (CCNY) https://www.carnegie.org/

CASA: CASA personal communications and Communication *training with medics, patients associations and patients in HIV and AIDA* http://www.casaproject.info/team-casa/

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CILIP Information Literacy Group Personal communications and http://www.cilip.org.uk/about/special-interest-groups/information-literacy-group

citizenscience.gov Helping federal agencies accelerate innovation through public participation https://www.citizenscience.gov/

Citizen Science Alliance https://www.citizensciencealliance.org/

Coalition on the Public Understanding of Science Personal communications and http://copusproject.org/

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IFLA Regional Office for Africa Africa-L http://www.ifla.org/regional-office-africa

IFLA Regional Office for Asia Oceania – Asia-L http://www.ifla.org/regional-office-asia-and-oceania

IFLA Regional Office for Latina America and the Caribbean http://www.ifla.org/regional-office-lac

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Cholera Prevention in Creole (accent from Haiti) - http://sawbo-animations.org/video.php?video=//www.youtube.com/embed/PMmRDXNloSw

Cholera Prevention in French (accent from Haiti) - http://sawbo-animations.org/video.php?video=//www.youtube.com/embed/G6aMoE8hamk

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Supporting education programs that use NOAA science to promote stewardship and informed decision making. http://www.noaa.gov/office-education/elp

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