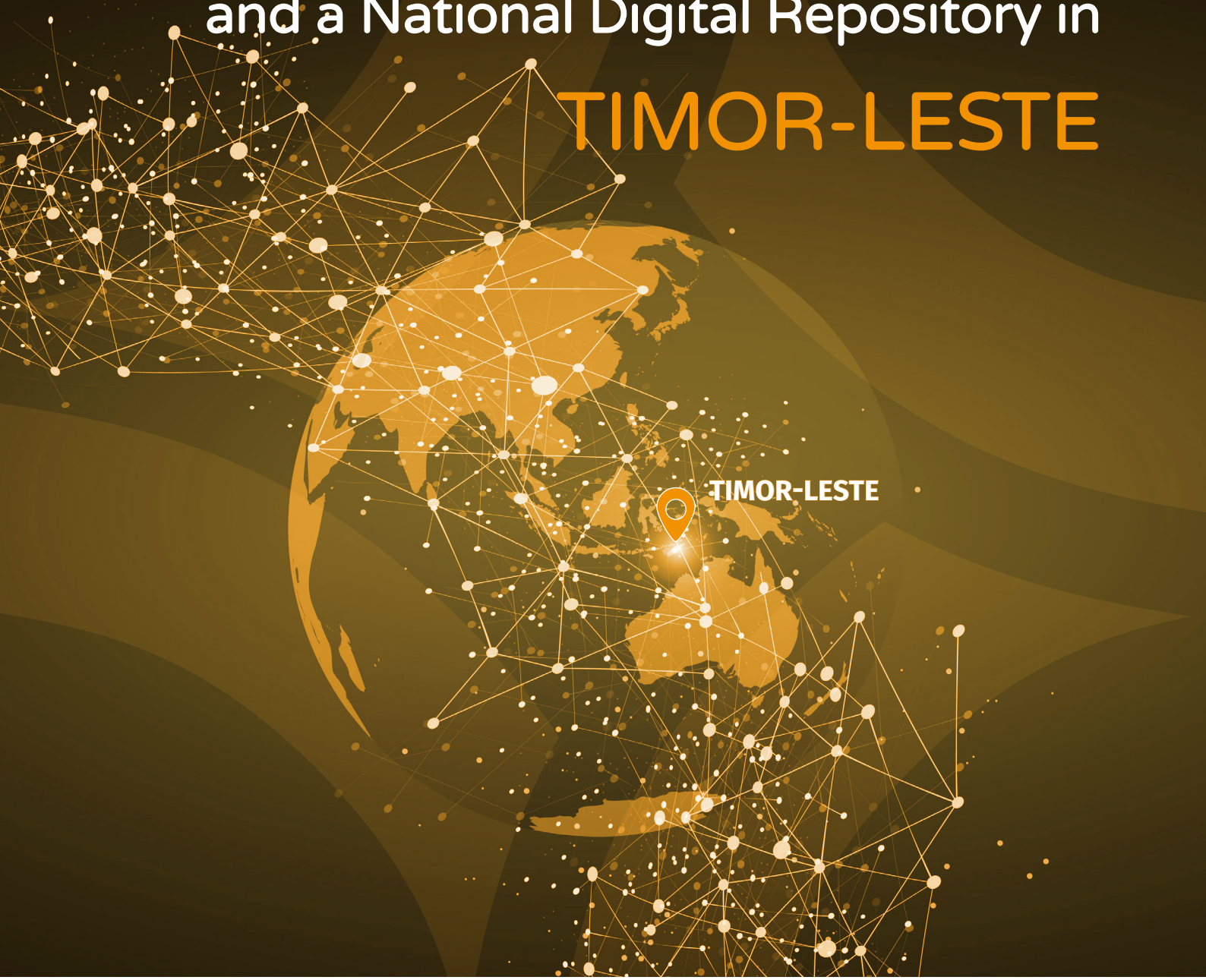
OACPS RESEARCH AND INNOVATION PROGRAMME

Policy Support Facility

PSF Policy Recommendation Report for developing an STI policy framework and a National Digital Repository in TIMOR-LESTE



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ORGANISATION OF AFRICAN, CARIBBEAN AND PACIFIC STATES (OACPS)

OACPS R&I PSF

Policy Recommendation Report

TIMOR-LESTE

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List of Abbreviations

ACP	African, Caribbean and Pacific
API	Application Programming Interface
APC	Article processing charges
CC	Creative Commons
CPLP	Comunidade dos Países de Língua Portuguesa
CSO	Civil society organisation
DIO	Digital object identifier
EOSC	European Open Science Cloud
EthERNet	Ethiopian Research and Education Network
EU	European Union
FAIR	Findability, accessibility, interoperability and reuse
FCCN	Fundação para a Computação Científica Nacional
FCT	Fundação para a Ciência e a Tecnologia
GDP	Gross domestic product
HDI	Human Development Index
HEI	Higher education institution
HENP	Higher education national policy (January 2022)
ICR	Instituto de Ciências Religiosas
INCT	Instituto Nacional de Ciência e Tecnologia
IT	Information Technology
JPAL	Abdul Latif Jameel Poverty Action Lab
LAC	Library and Archives Canada
M&E	Monitoring and evaluation
MDG	Millennium Development Goals
MESCC	Ministério do Ensino Superior, Ciência e Cultura
MVP	Minimum viable product
NADRE	National Academic Digital Repository of Ethiopia
NDR	National Digital Repository
NIS	National Innovation System
NSI	National systems of innovation
OACPS	Organisation of African, Caribbean and Pacific States
OAI-PMH	Open Archives Metadata Harvesting Protocol
OER	Open educational resources
Open-DOAR	Directory of Open Access Repositories
PESTEL	Political, economic, social, technological, legal and environmental factors
PID	Persistent identifier
PSF	Policy Support Facility
R&D	Research and development
R&I	Research and innovation
RCAAP	Repositorio Científico de Acesso Aberto de Portugal
RIN	Reporitori Ilmiah Nasional
RREN	Regional Research and Education Network
RRI	Responsible research and innovation
S&T	Science and technology
SDGs	UN Sustainable Development Goals
SMU	Singapore Management University
STI	Science, technology and innovation

SWOT	Strengths, weaknesses, opportunities and threats analysis
TH	Triple helix model
TIC	Telecommunication Information Communication
UNDP	United National Development Programme
UNPAZ	Universidade da Paz

Glossary of terms and definitions

Citizen science[1]

Citizen science is any activity that involves the public in scientific research and thus has the potential to bring together science, policymakers and society as a whole in an impactful way. Through citizen science, all people can participate in many stages of the scientific process, from the design of the research question to data collection and volunteer mapping, data interpretation and analysis, and to publication and dissemination of results. Citizen science is also an approach of scientific work that may be used as part of a broader scientific activity.

e-Infrastructure[2]

e-Infrastructure is 'an environment where research resources (hardware, software and content) can be readily shared and accessed where necessary to promote better and more effective research; such environments integrate hard-, soft- and middle-ware components, networks, data repositories, and all sorts of support enabling virtual research collaborations to flourish globally'.

FAIR data principles[3]

FAIR guiding principles for scientific data management and stewardship are findability, accessibility, interoperability and reuse of digital assets.

Open access[4]

Open access (OA) refers to the practice of providing online access to scientific information that is free of charge to the end-user and reusable. 'Scientific' refers to all academic disciplines. In the context of research and innovation, 'scientific information' can mean:

- peer-reviewed scientific research articles (published in scholarly journals) or
- research data (data underlying publications, curated data and/or raw data).

Open data[5]

Data is open if it is free to use, re-use or redistribute, subject to measures that preserve provenance and openness.

There are two dimensions of data openness:

1. The data must be legally open, which means they must be in the public domain or under liberal terms of use with minimal restrictions.

2. The data must be technically open, which means publication in electronic formats that are machine readable and non-proprietary, so that anyone can access and use the data using common, freely available software tools. To make open data easier to find, most organisations create and manage open data catalogues.

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1 EU-Citizen.Science, Citizen Science, 2021; https://eu-citizen.science/, last accessed 30 April 2022.

2 H2020 Programme, 4. European research infrastructures (including e-Infrastructures), 2014; https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/main/h2020-wp1415-infrastructures_en.pdf, last accessed 30 April 2022.

3 Go FAIR. FAIR Principles, 2022; https://www.go-fair.org/fair-principles/, last accessed 30 April 2022.

4 H2020 Programme, Guidelines to the rules on Open Access to Scientific Publications and Open Access to Research Data in Horizon 2020, 2017; https://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-pilot-guide_en.pdf, last accessed 30 April 2022.

5 The World Bank, Open Data Essentials, 2019; http://opendatatoolkit.worldbank.org/en/essentials.html, last accessed 30 April 2022.

Open educational resources[6]

Open educational resources (OER) are learning, teaching and research materials in any format and medium that reside in the public domain or are under copyright that have been released under an open licence, that permit no-cost access, re-use, re-purpose, adaptation and redistribution by others.

Open science[7]

Open Science refers to efforts to make the output of publicly funded research more widely accessible in digital format to the scientific community, the business sector, and society more generally' and so promotes the usability of scientific results more widely.

Policy

Policy is used in the document to mean a set of guidelines, interrelated plans and actions by a government to achieve specified goals. Formally and theoretically, a new policy begins with identification of a problem and a goal, followed by data collection on the problem, moving through stakeholder consultations, agenda setting, decision-making, creating new rules as required, implementation and evaluation.

Quadruple helix of innovation[8]

The quadruple helix of innovation is a form of collaboration/co-creation in research and development between the four major sectors of society: industry, government, academia and research institutes, and the society.

Responsible research and innovation[9]

Responsible research and innovation is:

- involving society in science and innovation 'very upstream' in the processes of research and innovation (R&I) to align its outcomes with the values of society.
- a wide umbrella connecting different aspects of the relationship between R&I and society: public engagement, open access, gender equality, science education, ethics and governance.

Science, technology and innovation (STI) policy

This follows the framework set for policies above, and focuses on the contribution of STI to a country's social and economic development, setting priorities for public investments in the national STI ecosystem, allowing for greater focus on research, on problem areas such as output, energy, environmental or health issues, and promoting stakeholders to work within a common vision of the future goals, and to facilitate coordination within the STI ecosystem.

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6 UNESCO, Open Educational Resources, 2022; https://www.unesco.org/en/communication-information/open-solutions/open-educational-resources, last accessed 30 April 2022.

7 OECD, Making Open Science a reality; https://www.oecd-ilibrary.org/science-and-technology/making-open-science-a-reality_5jrs2f963zs1-en, last accessed 30 April 2022.

8 European Union , Using the quadruple helix approach to accelerate the transfer of research and innovation results to regional growth; https://op.europa.eu/en/publication-detail/-/publication/6e54c161-36a9-11e6-a825-01aa75ed71a1, last accessed 30 April 2022.

9 RRI Tools. Welcome to the RRI Toolkit; https://rri-tools.eu/, last accessed 30 April 2022.

Executive Summary

This report has been prepared within the framework of the Organisation of African, Caribbean and Pacific States (OACPS) Research and Innovation Programme, with funds provided by the European Union (EU). The report describes the work undertaken at the request of the National Institute for Science and Technology / Instituto Nacional de Ciência e Tecnologia (INCT), Timor-Leste.

Timor-Leste has the goal to achieve the targets laid down in its localised Sustainable Development Goals (SDGs), which include enhanced economic growth, and the reduction of poverty and inequality. Important for their achievement are enhanced human resource capacity, utilisation of its natural resource endowments, and the development and diversification of various economic sectors.

The above requires access to knowledge that is generated within the country and abroad, and the use of such knowledge is becoming more important. In an era of digital technology it is important to catch up with the increasing speed of knowledge creation and knowledge use. Towards this, the government has asked the INCT to develop a gateway to international knowledge, and thus facilitate and stimulate the absorption of (inter)national knowledge within Timor-Leste.

INCT is the designated national public institute, which is provided with a legal personality and administrative autonomy, and, given the mission to promote scientific and technological knowledge in Timor-Leste, to stimulate its diffusion, and promote practical applications for the improvement of welfare in the country.

This report presents the results of the policy interactions between the national stakeholders and the external team of experts, responding to the national request to undertake two feasibility studies. First, for setting up a science, technology and innovation (STI) policy framework and prioritised programme, keeping in mind the national context; and second, for the creation of a National Digital Repository. The National Digital Repository (NDR) is to form one critical element in the STI policy framework and actions for the country.

The STI strategy and framework that have been proposed here are based on open science and global digitisation trends, and follow an inclusive approach, led by the INCT, in cooperation with all key stakeholders. The policy framework and action built on the National Strategy 2030 and the recent 2022 national policy for higher education and science are based on the environment context analyses (SWOT, PESTEL) undertaken for this report.

The report describes an STI policy framework that builds on four pillars: Pillar 1: STI programme formulation; Pillar 2: National Digital Repository; Pillar 3: open science cloud (e-Colaboratorio National); Pillar 4: physical infrastructure. The need for the first two pillars and many of the details are explained in this report; while for the pillars 3 and 4, the report advises the initiation of additional feasibility studies. For all the pillars, it is important to allocate funds, based on longer term visions, organise national communities of stakeholders and to invest in human resources via training, awareness programmes, networks and connections between science, government, economy and society.

For the planned NDR, it is recommended that the INCT should follow a minimal viable product (MVP) approach that starts with a repository, possibly with initial limited functions, but that is scalable in both content, functionality and number of users over time. The report provides detailed points for the operationalisation of the NDR, including suggested staff needs, training, capacity building and anticipated resource requirements. The next step for the realisation of the NDR would be to set up an exploitation plan, with the required capacity building.

An important recommendation, for both the STI policy and the NDR, are the sustainability and continuity of actions. This refers to annual budgeting, but also to setting up communities and networks, and an evidence-based monitoring system to share with all stakeholders what is working well and what changes are needed. The operationalisation of the STI policy actions requires the cooperation of the many different actors and stakeholders, and local ownership and leadership.

A general recommendation is to work together on STI policy and open science actions in national coalitions with major data service providers, including the National Statistics Office, and form international partnerships, e.g. within the OACPS framework, or in regional settings.

The report is structured as follows: **Chapter 1** introduces the main players and the scope of the report. In **Chapter 2**, the methodology used for arriving at the report and the processes of collaboration and the limitations are described. The context of Timor-Leste is discussed in **Chapter 3**, which notes that an appropriately defined and implemented STI policy has been lacking in the country until recently, while the new policy on higher education, published in January 2022, is an important step towards formulating and implementing STI policies for the development goals, which promotes a new emphasis on public research. **Chapter 4** describes the science, technology and innovation context and framework most relevant for Timor-Leste. Based on an inclusive approach and environment analysis, four pillars are developed to set up a STI policy framework. **Chapter 5** covers the planned National Digital Repository. It includes discussions on the types of repositories, examples of existing repositories in other countries and the anticipated benefits. The report ends with a short section in **Chapter 6** on conclusions and recommendations.

1 Introduction

1.1 BACKGROUND

1.1.1 OACPS R&I Policy Support Facility

The Organisation of African, Caribbean and Pacific States (OACPS)[10] has launched a framework of support for research and innovation (R&I): the OACPS R&I Programme[11], funded by the European Union (EU).

The R&I Policy Support Facility (R&I PSF) is a component of the OACPS R&I Programme, which provides policy support through technical assistance to enhance the quality and efficiency of R&I systems in the African, Caribbean and Pacific (ACP) member states and assists the members to unlock their innovation potential. The PSF is a demand-driven policy support tool that responds to requests for national R&I policy reforms and adaptations, based on national needs as identified by high-level authorities from the OACPS member countries.

1.1.2 The PSF service in Timor-Leste

The main objective of this PSF service to Timor-Leste was to carry out two feasibility studies, which are covered in this report as two separate chapters:

a. **A study for the setting up of a specific STI policy framework and programme actions** to enhance the cooperation between government, higher education institutions (HEIs), industry and civil society, which has been undertaken along the quadruple helix of the innovation model. The report provides information on the operational aspects of such a programme and discusses, among others:

- reasons for setting up a STI policy, with specific actions in which the programme formulation is included;
- cooperation between the stakeholders to foster open innovation;
- creating partnerships as a priority theme;
- open science as a priority line, embedded throughout the STI policy actions;
- the needs to operationalise:
  - the expertise required for the implementation of the STI policy actions;
  - the timeline of the STI policy actions, including the programme formulation;
  - the training of local experts to further enlarge the STI policy actions in the future;
  - an overall and detailed budget.

b. **A feasibility study for the creation of a NDR** to place it within the larger policy for higher education and the STI policy framework above. It describes how to manage and access digital-based scientific research results, both from national research institutions and through connecting to other international digital repositories. This will open results of research conducted by national and international researchers, not only to scientists but also to society at large (including industry and services).

10 The Organisation of African, Caribbean and Pacific states (OACPS), known previously as the African, Caribbean and Pacific (ACP) Group of States, is a pan-national organisation of 79 members from Africa (48), the Caribbean (16) and the Pacific (15). The OACPS Secretariat is located in Brussels, Belgium (for more details see http://www.acp.int/node).

11 www.oacps-ri.eu

The report provides information on the operational aspects of setting up a repository, among others:

- An explanation on the functionality and roles of repositories:
  - a description of several existing repositories to show possible functionalities, not only for research and access to knowledge, but also for developing science policy;
- Designing a National Digital Repository:
  - using a minimal viable approach to start fast and develop over time;
  - its functionality and scope;
  - using standards to empower search, international sharing and access content;
  - describing the process to set up a repository;
- Building the repository:
  - implementing standards and identifiers for search and ensuring interoperability;
  - designing the repository;
  - detailing the required expertise for the set-up of the repository, including copyright and multilinguality;
- Realising and sustaining the repository:
  - management and maintenance, including detailed technical information;
  - training experts and users, including procedures for uploading content, cataloguing and access;
  - outreach and promotion of use;
  - budget, and
  - a timeline for both the initial phase and further development.

1.1.3 INCT

The National Institute for Science and Technology / Instituto Nacional de Ciência e Tecnologia (INCT) requested technical assistance from the OACPS Secretariat for a policy support service for Timor-Leste.

The INCT, established in 2014, is a public institute, with a legal personality and administrative autonomy, both financial and patrimonial, as well as with scientific and editorial autonomy, with the possibility to be inspected in accordance with the law and the current statute. Its mission is to promote scientific and technological knowledge in Timor-Leste, to stimulate its diffusion and promote practical applications for the improvement of welfare in the country, in line with the National Strategic Development Plan (2011-2030)[12], the UN Sustainable Development Goals (SDGs) and the new policy, the higher education national policy (HENP), promulgated on 26 January 2022, which calls for an inclusive, open and sustainable STI strategy and framework, led by INCT, in cooperation with all key stakeholders and especially focused on fully covering linkages between the strategic plan for the HENP. The INCT has the role to develop and consolidate the national system of science and technology, research, development and innovation in strategic areas:

- To promote, monitor, evaluate and articulate activities in science and technology, particularly those related to the Plano Estratégico de Desenvolvimento (PED) 2011-2030;
- To promote the training and qualification of human resources;
- To promote the creation and strengthening of support

12 Decreto do Presidente da República No 3 /2022, de 26 de Janeiro, pps. 147-179.

infrastructures for scientific research and technological development in higher institutions;

- To promote the dissemination and divulgence of cultural, scientific and technological knowledge, and the teaching of science and technology; and provide data and information of national interest.

Within the scope of scientific autonomy, the INCT may define, programme and carry out research activities of a scientific nature at national and international level. Amongst others, it can:

- promote studies on the general condition of scientific and technological knowledge and research in Timor-Leste, identifying priority areas and submitting recommendations;
- define and budget the priority areas for research annually, together with other scientific and technological activities carried out by the institute;
- cooperate with universities and other institutes of research and technological education in the development of scientific research and training of researchers;
- maintain relations with national and foreign institutions to facilitate the exchange of scientific and technical documentation;
- promote the formation and improvement of courses, seeking the interaction with local universities;
- encourage the dissemination results of research and the awarding of prizes for works of a scientific nature, which contribute to the development of society and welfare in Timor-Leste;
- support the teaching, research and extension projects of institutional, scientific and technological development of interest to higher education and scientific and technological research institutions;
- establish standards of national and ethical importance;
- make a mandatory registration of national and international scientific studies generated in Timor-Leste, as well as in the results of surveys;
- serve as a repository for science and technology.

1.1.4 Transfer of knowledge

A goal of the OACPS PSF support is to emphasise that policies are not only well articulated, but also well implemented. The development and operationalisation of the policy requires the cooperation of all the actors and stakeholders, and local ownership and leadership. For this reason, it was a priority of the international team of experts to work very closely with a national team of experts and stakeholders. The intent was not only to prepare this report, but also to work jointly via meetings and workshops, in order to arrive at recommendations that are relevant to the national context, to 'co-create' and organise this report and recommendations for actions, so that they are owned by the national authorities, promoting a smoother implementation of both the STI policy and the National Digital Repository.

1.2 STRUCTURE OF THIS REPORT

Subsequent to the description of the goals set for the service provided and its nature above, the methodology used for arriving at the report and the processes of collaboration and the limitations are described in **Chapter 2**. **Chapter 3** contains a brief description of the context of Timor-Leste, its status on STI policy and access to publications and other research outputs, and the roles of the different stakeholders. **Chapter 4** begins with a short description of the science, technology and innovation context and framework most relevant for Timor-Leste, including key issues of priority in moving forward with plans for the future. It provides information on the political, economic, social, technological, environmental and legal (PESTEL) and the strengths, weaknesses, opportunities and threats (SWOT) analyses undertaken, a discussion of the quadruple helix for innovation, open science and the infrastructure required, with the role of the national repository in the suggested STI policy actions for Timor-Leste, supported in four pillars. It details issues for the operationalisation of the STI programme and the suggested overall national budget targets. **Chapter 5** covers the planned National Digital Repository in complete detail. It includes discussions on types of repository, choices for Timor-Leste and examples of existing repositories in 6 other countries. It covers specific recommendations for the governance and resources, processes, and the resources required. The report ends with a chapter on conclusions and recommendations[13].

13 This report is prepared by the international team of experts, working closely with INCT and the national team of experts and stakeholders. Their input and participation were valuable to co-create and organise this report and recommendations for actions, which are owned by the national authorities, especially the INCT, to promote a smoother implementation. The report has also benefited greatly from the input from different ministries to the questionnaires used by the international team.

2 Methodology

2.1 PROCESS

The team of experts started by doing desk research and working on the primary and secondary data received from INCT and other national sources in order to form the basis for a preliminary and mutual understanding of the issues and the context. The national stakeholders assisted in the problem identification, the needs at the technical level, and an understanding of the nature of the situation on the ground, including both expressed needs and possible solutions. Online interviews and questionnaires were used to substitute for the disruption on planned face-to-face meetings in Dili (see **Annex A**).

The stakeholders were grouped into four categories, following the quadruple helix concept, namely:

- representatives of academia;
- representatives of national government and public administration;
- representatives of the IT and productive sectors;
- civil society representatives.

The direct partners of INCT are individual researchers at academic institutions, the government and the public administration. They are considered key partners and will work closely with the INCT once the repository has been established. Other, more indirect partners include representatives from IT (information technology) and industry. These stakeholders may contribute to the STI policy actions implementation, but are also important providers of IT services and potential users or beneficiaries of both the STI policy and the digital repository once this has been completed (see **Annex E** for list of stakeholders contacted).

The next step was to continue with online interviews, based on questionnaires. This was undertaken with all the experts together to understand the needs and context of Timor-Leste specific to the two tasks. Next there were in-depth interviews with specific groups. The experts conducted 5 interview sessions with relevant stakeholders (representatives of the IT sector, representatives of academia, representatives of the national government and public administration, representatives of the industry sector) and worked together with the national team and the INCT. Questionnaires were also sent to the ministries involved: one dedicated to the Ministry of Higher Education, Science and Culture, and one for the other ministries.

Two virtual workshops were organised with decision-makers. The first focused on STI issues, with the systems mapping, and PESTEL and SWOT analyses deriving from it. The second workshop focused on the repository, with a processes swimlane diagram being generated, along with the rapid prototype for the repository. In these workshops, co-creation approaches were implemented to drive the ownership and engagement of the different key stakeholders involved.

The Expert Panel has also held different meetings and reviews of the draft report with the PSF team and the INCT, the national team

and many other national stakeholders. Their input has been incorporated into this final report, which allowed for differences in views to be clearly stated, but there were none.[14] Subsequent to the preparation and review of this final report, the expert team organised several events: a capacity building workshop for key national stakeholders, a report validation workshop, and an online regional workshop on open science.

Two capacity building co-creation workshops took place as part of the knowledge transfer to further identify and sustain the NDR minimum viable product development until 2023. The results are summarised in this report, including an evaluation rubric for choosing the NDR software tool in **Annex D**.

The report was discussed at the final validation workshop with key stakeholders. There were minor additions and, overall, a very positive response to the report.

14 The work required a thorough understanding of the local context, and interactions between the external team members with the local partners, where the output would combine the knowledge and experience of the team with the national expertise and their understanding of the local context, as well as the future demands for the services. The face-to-face communications, meetings and workshops that had been planned could not be undertaken due to travel restrictions related to the COVID-19 pandemic. The work was undertaken with the acknowledgement of the risks and limitations from the lack of field visits and physical contacts with stakeholders.

3 Background information

3.1 TIMOR-LESTE

Timor-Leste became an independent country in 2002, after a long period of struggle, civil unrest and conflict, and is a recent member country of the United Nations in Asia. Yet it ranks as one of the most democratic nations in Southeast Asia, according to The Economist Intelligence Unit's latest Democracy Index[15]. The nation has committed itself to the goals of reconciliation and inclusion, to building up the institutions supporting democratic development and to the goals of sustainable development. Timor-Leste has a population of 1 280 743 (Projection 2019, GDS), around 70 % of whom live in rural areas. The country is divided into 13 administrative districts, 65 administrative posts, 442 sucos (villages) and 2 225 aldeias (hamlets). Most communities are in remote mountainous locations with poor roads and telecommunications.

Education levels are a challenge but also provide opportunities. In rural areas, only 62 % of women are literate (compared to 72 % of men), while 90 % of children are enrolled in basic education. Timor-Leste has one of the youngest populations in the world, with 62 % of the population under the age of 25. The youth population (aged 15-24) is expected to grow by 70 000 between 2010 and 2020.[16] This offers great economic potential, if families and the government invest in health, education and skills development for the youth.

Timor-Leste ranks 141 out of 189 countries in the Human Development Index (HDI, 2020), placing it in the medium human development category. It is making laudable progress, indicated by the fact that between 2000 and 2019 the HDI increased by 25.2 %; overall life expectancy increased from 59 years to 69.5 years in the same period (HDI, 2020). The government has identified gender equality as a priority for realising national development goals. The government's health budget in absolute terms has increased from USD 38.19 million to USD 67.2 million between 2011 and 2014. There is 1 national tertiary level hospital, 5 regional referral hospitals and 70 community health centres at sub-district level (GDS, 2019). Among its successes is the fact that it has successfully brought malaria under control, with a 75 % decline in the incidence of cases between 2000 and 2014. The World Health Organisation (WHO) honoured the Timor-Leste National Malaria Control Programme with an Award for Excellence in Public Health, noting that Timor-Leste had achieved its Millennium Development Goals' (MDG) target for malaria. Leprosy has been declared eliminated as a public health problem; maternal and neonatal tetanus have also been eliminated.

The investments in hard and soft capacity in public health have shown results as they allowed the country to manage the threat to public health from the COVID pandemic, with high levels of vaccination, and public policy measures that have limited prevalence to 22 784 confirmed cases of COVID-19 with only 129 deaths until March 2022[17]. The relative success in the reductions of the disease

15 See Does Timor-Leste's Upcoming Election Herald a More Inclusive and Progressive Democracy? Li-Li Chen, 11 March 2022. The ranking by the Economist is available at https://www.eiu.com/n/campaigns/democracy-index-2020/

16 Rath, Amitav (2020), p. 10, based on the latest (2015) Timor-Leste population and housing census data available.

17 Source: World Health Organisation, for 1 March 2022; https://covid19.who.int/region/searo/country/tl. The numbers are lower than the global infection and death rate of 29 155 cases and 599.6 deaths per million, and lower than the neighbouring countries in Southeast Asia.

burden is indicative of robust investments and capacities in public health in terms of human resources, knowledge, facilities, testing capacity, and the resiliency of people and institutions. For example, in the past 24 months, the capacity to perform COVID-19 tests was improved, monitoring systems were expanded, and a public education campaign was undertaken. The government responded with a state of emergency (now lifted) to manage all activities, and created a special ad hoc committee called the Integrated Centre for Crisis Management, which ensured the implementation of effective measures, despite turmoil in the ruling parliament in June 2020. The government also adopted an economic stimulus package worth 10 % of GDP to reinforce the public health measures, while protecting vulnerable households and the business sector.[18] However, with a global economic disruption and impact on the economy, the United Nations Development Programme (UNDP) reports that Timor-Leste experienced the largest gross domestic product (GDP) contraction since its independence, with an expected real GDP per capita to fall to the 2009 level. Timor-Leste's non-oil sector, mostly in agriculture and small enterprises, are squeezed with 81.0 % of micro, small and medium-sized enterprises reporting a loss of income.

A signal achievement of the country has been the creation of a sovereign wealth Petroleum Fund in 2005, where the proceeds of its natural oil and gas resources are deposited for the benefit of current and future generations. It has used large withdrawals from the fund to frontload infrastructure, provide electricity and rehabilitate the devastated road network. The country should plan to ensure future withdrawals are used to invest strategically in the drivers of growth – human capital and economic diversification. Timor-Leste has built independent human rights, anti-corruption and electoral institutions, and enhanced accountability and is committed to achieving all the SDGs in order to work for a just and inclusive society. The government has highlighted the many challenges that remain – for improving incomes, quality education and healthcare, especially in rural communities, and for children. Timor-Leste has one of the highest malnutrition rates in the world. Timorese children have the highest levels of stunting and wasting in the region, at 50.2 % and 11 % respectively. Moreover, 37.7 % of children under the age of 5 are underweight, down from approximately 46 % in 2001. The prevalence of reported low birth weight is 10 %.[19] Malnutrition among women remains a serious concern, although the trend shows some improvement. Timor-Leste faces critical challenges with an overdependence on oil revenues, while poor productivity hampers health and education and makes for high youth unemployment. Without increased education and higher food production, the above issues cannot be addressed.

The total value added in 2014 in agriculture, forestry and fishing was only USD 283.7 million, and these are the occupations of over 70 % of the population. Manufacturing and other industry accounted for USD 12.2 million; real estate, construction and trade and transportation was USD 234 million; health and social services, largely provided by the government, accounted for USD 350

18 Timor-Leste's Coronavirus Response, Fidelis Magalhães, Minister of Legislative Reforms and Parliamentary Affairs, and acting Minister Coordinator of Economic Affairs, 4 May 2020; https://thediplomat.com/2020/05/Timor-Lestes-coronavirus-response/

19 Rath, Amitav (2020), p. 11, based on the HDR analysis and report for Timor-Leste, available at http://www.hdr.undp.org/en/countries/profiles/TLS

million; and value added in sectors such as information and communications accounted for USD 43 million.[20]

The World Risk Report (2021) classifies Timor-Leste as the 16th most-at-risk country, due to its exposure to natural hazards and a high vulnerability caused by the limited adaptive and coping capacities of its population, and of national and local structures to prevent and mitigate the effects of disasters. Natural hazards in Timor-Leste are mostly caused by strong wind, flood, fire and landslide. The impact of climate change in the country includes increased temperatures both on land and the sea's surface, a rise in sea-level and increased ocean acidification; increased and variable rainfall with a likely increase in the variability; and increased hazard events of flooding, landslides, storms and droughts.

There are also challenges in policy and planning, coordination and financial management – including delayed budgets and execution (with high end-of-year budget execution rates). It is in the early stages of integrating plans, budgets and monitoring and evaluation (M&E) systems.

As previously stated, among the key challenges are that more than 70 % of its population is in rural areas, often in remote mountainous locations with poor roads and telecommunications, and while almost all the population is reliant on agriculture, forestry and fishing, the activities only generate USD 283.7 million in outputs, less than 10 % of the GDP. Also, there is large percentage of young people who need education and skills to work gainfully in an economy with a very small job market. Timor-Leste needs a greater investment in education and skills and improved productivity, especially in the labour-intensive sectors of tourism, trade, agriculture and some manufacturing. Timor-Leste has many achievements to build upon: the commitment to reconciliation, inclusion and democracy, with independent human rights, anti-corruption and electoral institutions, and the sovereign wealth fund to manage its oil revenues are noteworthy, as are some gains in infectious diseases and vaccinations.

Investing more in human capital is a priority for sustaining development and economic growth. Better education and health will contribute to a healthy and productive population. There is also a need for quality primary, secondary, vocational and higher education to create the human capital necessary to develop and use science and technology for innovations that can, in turn, create opportunities for the large numbers of young people and drive new areas of economic growth. Agriculture and rural activities currently employ over 80 % of the people of Timor. The Voluntary National Review of the SDGs by the government has identified 4 main areas for accelerating progress and, for the first time, national planning documents have emphasised the possible roles for STI to achieve the SDGs. The current Strategic Development Plan 2011-2030 is built around 4 pillars:

1. Social capital: health, education and social protection;

2. Infrastructure: transport, telecommunication, power, and water supply and sanitation;

20 Source; Agriculture trends in Timor-Leste from 2010-2015, available at https://www.statistics.gov.tl/category/publications/census-publications/

3. Economic foundations: three sectors for development – agriculture, tourism and petrochemicals – to bring about growth, jobs and new sources of public revenues beyond oil;

4. Institutional framework: focusing on macroeconomic management, and improving the capacity and effectiveness of government institutions.

The SDG pillars depend upon building the national capacities for knowledge creation and dissemination, where knowledge is made available easily and cheaply to people who can build on that knowledge for new and improved services and products, or what is called 'innovation'. New ideas and new knowledge are always expensive to generate, but always less expensive to share, re-use and build upon. Hence the planned repository is one important next step for Timor, for its future and for sustaining greater innovation, technologies and human capacities through its storage and open access to all users.

It is noteworthy that in January 2022, during the engagement period for this report, the national government released a new policy document on higher education that also gives new weight to national commitments to STI, and reiterates the roles that the INCT will need to fill (discussed in more detail in the next chapter). This report acknowledges the national needs for more effective investments in human capital with a priority attention to higher education, together with efforts required in primary, secondary and vocational education, and lays considerable emphasis on the links between higher education and science and technology for innovations.

4 The STI policy framework

This chapter sets out an overall STI policy framework, starting with a general introduction to STI and introducing the quadruple helix model with its four stakeholder groups, and an analysis of the STI environment for Timor-Leste. Based on the framework and concepts, 4 main pillars are proposed to elaborate national STI policy actions. Coordination, networking, monitoring and communication between multiple actors in the national arena are essential for fostering STI in all countries, and so also in Timor-Leste. It was noted earlier that STI policy has not been a priority in Timor-Leste until recently, with a new policy on higher education, HENP.

4.1 CONTEXT

4.1.1 Science and technology

Prior to detailed discussions on policy, it might be useful to clarify the separate elements of science, technology and innovation and their interactions.

In brief:

- Science is a system of knowledge that is acquired using specified methods of observation, description, experimentation and validation, but too often is used narrowly to describe the tools and research practice.

- Technology involves the combination of knowledge with machinery, materials, energy and other input to produce a socially (or economically) desirable product or service.

It is good to realise that science is one form of systematised knowledge; and that a given technology always includes a bundle of goods, within which knowledge may be a larger or smaller component but is never absent. It is also important to note that technology is not a piece of machinery alone: it includes the combined results of the skills of workers and technicians, standards, raw materials, designs, drawings, specifications and various other forms of knowledge, both codified and uncodified, or tacit knowledge (that is not specified in written form but comes from experience). The connections are critical.

All too often technology is narrowly defined, referring only to recent breakthroughs and work done at very great expense in prestigious research centres, such as the breakthroughs in vaccine development in 2020. Such radical breakthroughs cannot of course be ignored, and we discuss specifically the applications of digital storage and the retrieval of information for Timor-Leste below. But it is a mistake to focus narrowly on new frontier and frontier technologies alone, and ignore a number of other important facets of knowledge, science and technology.

Defined in this way, all socially useful activities embody within themselves sets of knowledge and techniques, and thus science and technology. This implies that policy in science and technology does not begin and end in one standard form, with only people and institutions involved with formal research and development (R&D), though they are one important constituent.

The larger body of knowledge includes traditional knowledge of medicines, ecosystems, social formations and the sustainable use of resources, which cannot always be ignored as outdated and superseded by improved knowledge systems. It also includes knowledge gained from more modern social experiments such as large-scale vaccinations and health delivery programmes, for example the programme undertaken in Timor-Leste to cope with the new challenges of COVID-19.

When referring to STI policy for development, the aims are the increased availability of all these forms of knowledge, to all individuals, institutions and societies, and also in the greater and more effective application of knowledge to economic and social activities, thereby enabling greater production, wealth, employment, health, environment and other components of sustainable development[21].

The importance of the increased and more effective role for STI in Timor-Leste stems from the ongoing and accelerating growth of science-based knowledge systems, and the revolutionary changes that are before us, due to new technologies which have made these possible. These new technologies, as discussed here on information storage and retrieval from a digital repository for example, can contribute to the accelerated growth of knowledge and its use in Timor-Leste.

4.1.2 Innovation

Science is necessary but not sufficient for technology; similarly R&D efforts are necessary but not sufficient for innovation. An older and more simplistic view has been that research undertaken in laboratories moved through a linear process into innovations that contributed to increased economic production and welfare. Technological innovation required linkages between the producers of knowledge and the users, and was a complex, interactive process. This is very different from the model where input from science lead directly to technology development. The simpler linear model has given way to the view of the 'national systems of innovation'[22] in which users, producers and businesses, research institutions, universities and governments all play different roles, which, interacting together, both create and utilise new products of science and technology.

An effective national system to create and utilise knowledge requires:

- an educated and skilled workforce;
- educational institutions that generate knowledge and train new people;
- scientific research laboratories;
- the production and dissemination of scientific and technical information – both the codified form in published media and the more intangible forms;
- a supporting infrastructure of institutions for standards, testing, design, computation , etc.;
- a production system that demands and uses new knowledge, and is able to increase its use of new technologies;
- a policy framework and resources that support each of the above and enable their close integration and interaction.

In any well-functioning NIS, no more than 10-20 % of the resources and people are allocated to the formal research subsystem.

21 Rath, Amitav (1990), OECD (2016), OECD Science, Technology and Innovation Outlook 2016, Policy Profile.

22 Rath, Amitav (2020).

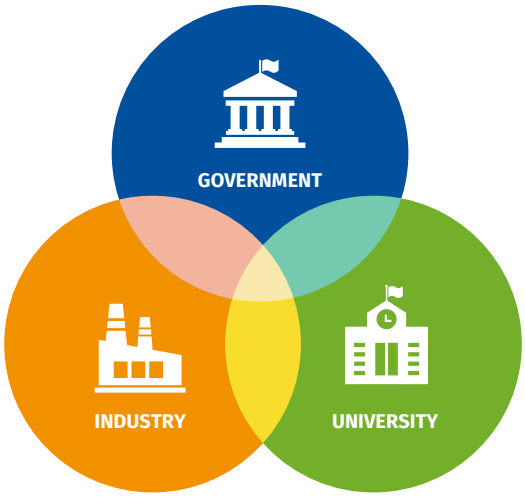
4.2 THE TRIPLE AND QUADRUPLE HELIX OF INNOVATION

There are a number of schematics that describe the complex web of interactions involved in a well-functioning STI system, within a region or a country. The triple helix model for innovation was first developed to highlight the synergy among universities, government and industry by Etzkowitz and Leydesdorff (1997)[23].

The triple helix model (TH) focuses on the interaction among the above three and emphasises that all three are key pillars, with an important role to generate innovations, and that the interactions between them are fundamental. This model has been expanded in the quadruple helix model where a role for civil society has been added, putting human beings and society at the centre of innovation, so as to be more aware of the impacts of technology and to ensure priority to improving quality of life, social responsibility and sustainability[24].

The quadruple helix of innovation is a form of collaboration/co-creation in research and development between the four major components of an innovation system: industry, government, research institutes and society. It incorporates the citizens and civil society as key parts of the helix, unlike the triple helix.

Figure 1 **Triple versus quadruple helix of innovation**



Source: Triple Helix (Etzkowitz and Leydesdorff, 2010)

Source: Quadruple Helix (Carayannis and Campbell, 2009)

23 Etzkowitz, H. and Leydesdorff, L. (1997), Introduction to Special Issue on Science Policy Dimensions of the Triple Helix of University-Industry-Government Relations.

24 Carayannis and Campbell (2009), 'Mode 3' and 'Quadruple Helix", doi:10.1504/IJTM.2009.023374

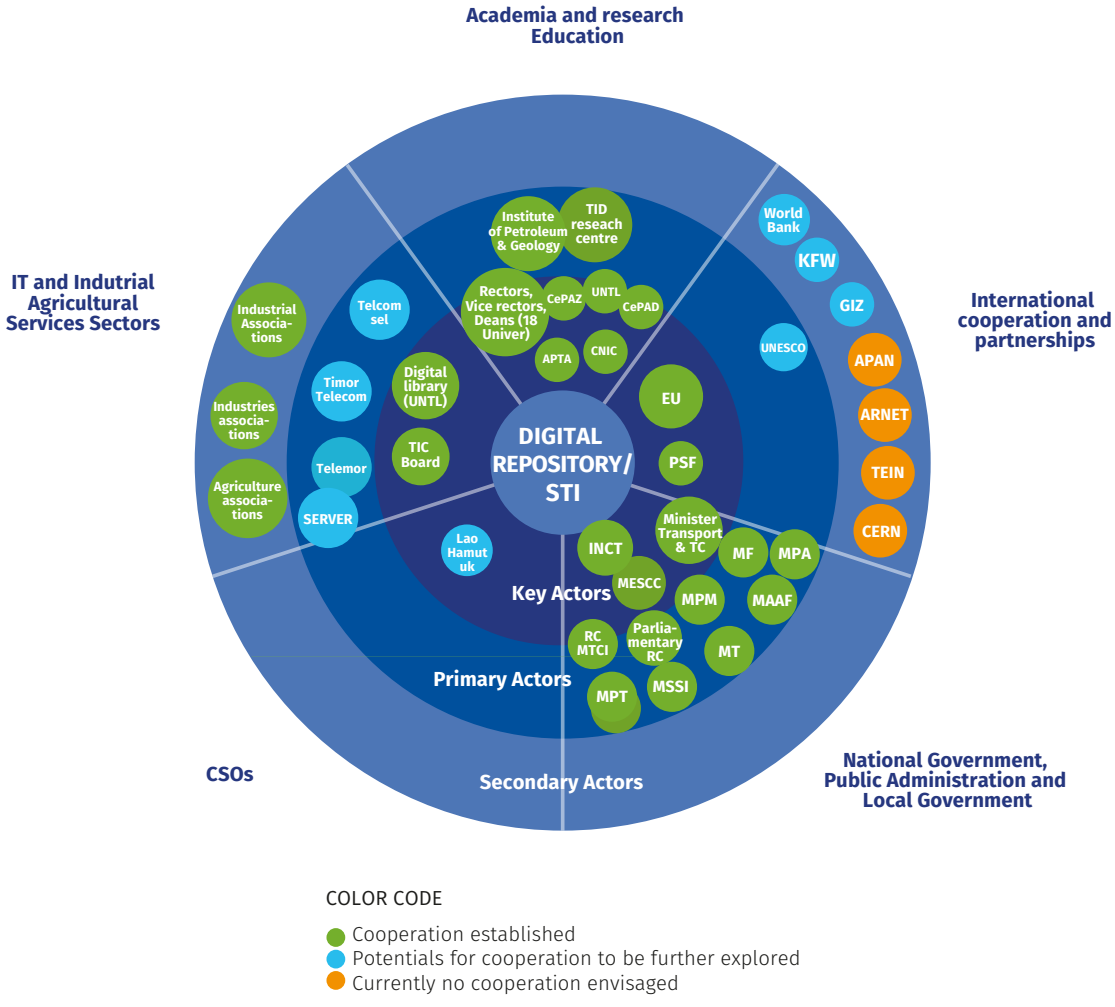
Civil society participation, important in the quadruple helix model, is also an intrinsic part of open science. As previously stated, the setting up of STI policies and programmes are full country endeavours, therefore it is of paramount importance to engage all the key stakeholders upstream and get not only their full buy-in, engagement and drive but also to tap into unexplored resources of knowledge, be it at traditional practices or out-of-the-box processes, for instance addressing market-creating innovations for non-consumers.

4.2.1 Stakeholders

To better understand the STI /NDR quadruple helix ecosystem, a key stakeholders' mapping analysis was carried out (see **Figure 2**).

In this analysis, international cooperation and partnerships were also envisaged. It is worth noting the lack of consideration for civil society organisations (CSOs) throughout the process, which required very specific, inclusive measures to include them throughout the STI processes.

Figure 2 **Key stakeholders' mapping**



COLOR CODE

- Cooperation established
- Potentials for cooperation to be further explored
- Currently no cooperation envisaged

Source: Authors' own elaboration.

The above diagram is an elaboration of the discussions on STI that combines quadruple helix models with stakeholders, and places the proposed STI/NDR at a central node[25]. The INCT, represented by its executive president, fulfils a special role, as previously described, and the statutes of INCT give the institute the authority to set up a STI programme and to organise a NDR. To set up such a programme, a STI policy is needed. The feasibility study on STI provides directions to elaborate such a STI policy actions, including the STI programme formulation. Similarly, the feasibility study on the NDR provides the parameters of such a system and the choices that can be made to set up such a repository.

The key stakeholders were grouped under the quadruple helix principles, the political leaders and the public administration, universities and researchers, and the private sector, with INCT at the centre of the helixes[26]. The process included consultations with (see **Annex E**):

- National government and public administration: the Research Department of the Ministério do Ensino Superior, Ciência e Cultura (MESCC), the Parliamentary Research Centre, the Research Departments of the Ministry of Trade, Commerce and Industries, the Ministry of Agriculture, Forest and Fisheries, the Ministry of Tourism, the Ministry of Finance, the Ministry of Public Health, the Ministry of Public Administration, the Ministry of Social Solidarity, the Ministry of Planning and Territories, the Ministry of Public Work, the Ministry of Transport and Telecommunication, the Ministry of Petroleum and Minerals, and the Telecommunication Information Communication (TIC) Timor-Leste (the public institute managing the IT connection of all public administrations networks in the territory).
- Representatives of academia: the 18 universities across Timor-Leste; and several research centres including the Digital Library and the National Centre for Scientific Investigation (CNIC) of Universidade Nacional Timor-Lorosa'e (UNTL), the Centro Estrategico da Paz (CePAZ) of Universidade da Paz (UNPAZ), the Asosiasaun Peskizadores Timor-Anan (the Timorese Research Association), the Centre of Studies For Peace and Development (CEPAD Timor-Leste), the non-governmental organisation (NGO) Lao Hamutuk, the TID Research Centre and the Institute of Petroleum and Geology, Timor-Leste.
- Among the stakeholders from the private sector, most notable was the IT sector, including Telcomsel (an Indonesian-owned company), Timor Telecom, Gardamor (Timor-Leste privately-owned companies), and Telemor (a Vietnamese-owned company). In other industry sectors, notable was SERVER Timor-Leste, the fertiliser industry, oil, fuels and natural gas, construction and renovation, heavy equipment/machinery, generators, furniture, machines, equipment, supplies, home essentials, food and beverages, primary industry (including agriculture and fisheries), transportation, logistics and courier services, ICT services and equipment companies, media and communication training, consulting and scientific services, financial and legal

25 It should be noted that other disgaramatic representations are possible and valid. The intent here is to include the key elements discussed in this report.

26 It is noted that consultations with general purpose NGOs and civil society representatives could not be undertaken.

services, restaurants and catering, health and medicine, security services and equipment, handicrafts and artisans, printing and copying, entertainment and leisure, goods and services, laundry, cleaning services and waste collection companies, associations, unions, cooperatives and NGOs. These key stakeholders, among others, outside the INCT are critical for engaging and driving the national STI policy and may benefit directly or indirectly once the digital repository has been established.

4.2.2 Internal and external linkages

Often the overall weaknesses of national systems for innovations in many countries stem from systemic challenges. Even after the supply side of the equation, such as building up educational and research facilities and increasing the supplies of trained manpower and resources for technology development, as envisaged in the HENP document, the weaknesses in dissemination of knowledge, the low demand for this output from the production units and a poor policy environment often results in poor innovation utilisation. The evidence suggests that capacity creation in numerical terms is much easier than moving from capacity creation to promoting the more complex, interactive system in which input on science and technology (S&T) becomes both necessary and sufficient to promote utilisation, development and growth.

Utilising knowledge is further complicated by the fact that only a very small percentage of the relevant knowledge and technologies are available within any single nation; much more is available through international flows. Thus, from the perspective of generation and utilisation of knowledge, not only is the national system of great importance, but the linkages of the national system to the larger sources of knowledge and technologies outside national boundaries are equally critical.

To illustrate the importance of linking national knowledge systems to those outside national borders, we will use one indicator of knowledge outputs. The fact that the country with the largest input of resources into S&T activities, the USA, is the source for 39 % of world scientific output in terms of publications and 45 % of the share of patents registered in Europe, suggests that even the USA must be open to sources of knowledge and technology from outside its borders, as the majority are produced outside its national boundaries. The issue becomes much more important as we look at smaller contributors to the world's growing stock of knowledge, as measured by scientific papers. The total numbers have jumped from around 2 million in 2010 to 3 million in 2020, with the top 15 countries, for instance, producing almost 76 % of scientific output measured in publications, while the remainder is produced by the almost 185 member countries of the UN.[27]

From the data on a low national share of the global knowledge pool, it is a major mistake to think that if the national contributions are in any case so small, a simple transfer of the knowledge and technologies from external sources can solve the development problems and national efforts. It has been found repeatedly that without a minimum level of internal capacity in knowledge production, one cannot transfer much useful knowledge from external sources. Higher cooperation efforts, South-South, and South-North, can only take place when the partners are willing to bring in experience and have a willingness to cooperate.

27 UNESCO (2021), p. 24. And the US NSF and NSB science indicators data, at https://ncses.nsf.gov/indicators

The appropriate size and scale of such capacity for different countries cannot be elaborated here, but a reasonable rule of thumb that has been the goal of many developing countries, but which few have attained, is to allocate at least 1 % of GDP to S&T promoting activities, and they must incorporate the different components of the NIS identified earlier. Finally, the national system must be networked into the larger knowledge networks of the South and the North.

4.2.3 Frontier technologies

It has already been mentioned that there are some key areas of scientific research and technological innovation that are driving the current wave of technological change, and these are driven by, among others, biotechnology, renewable energies, nanotechnology, artificial intelligence, Internet of Things (IoT), blockchain technologies and new materials. These new technologies are often difficult and costly to be the very first to develop, but once basic methods and tools have been developed, they are relatively easier to imitate and to use in production processes. They are supportive technologies, where capacity to produce the technology is possibly less important than the capacity to make use of it. As such, they offer vast opportunities for low and low-to-medium income countries to accelerate their economic progress and leapfrog over intermediate levels of technology.

4.2.4 STI and the role of INCT

The above issues, creating linkages, internal and external, examining and selecting emergent technologies for domestic applications, provide a special role for INCT, and examples are provided below. In Timor-Leste, as previously mentioned, the STI policy development is still in its very early stages. Below is a brief analysis of the role of STI policies and how they have been already addressed indirectly by the Timor-Leste Government and how the repository, discussed in the next chapter, can further sustain STI policy and programme implementation. For example, *science policies*, aimed to promote science and research, define and select scientific and research strategies aligned with national plans and international obligations, such as the Kyoto Agreement of 14 October 2008 and the Paris Agreement signed on 22 April 2016 by the Timor-Leste Government. Technology policies allow governments to steer the technological direction to improve social welfare, wellbeing and sustainability by influencing the rate and direction of technological change being made through the introduction of new technologies and infrastructures. The Timor-Leste Government's approval of the deployment of a submarine fibre link connecting the south of the country to Australia, via the North Western Cable System (NWCS), is a great example of this.

The additional and new STI policy actions and programme, to be led by INCT, should aim to create schemes that will foster co-creation, participatory approaches and partnerships with research, the public sector, industry, HEIs and CSOs, including grassroots and other organisations that are focused on reducing the gender gap in science, technology, engineering and mathematics (STEM), promoting entrepreneurship and innovation and the inclusion of indigenous knowledge and youth, and be aligned with the newly announced policy on higher education.

The planned NDR can allow the involvement of a wider public in scientific research efforts, and so can bring together science, policymakers and society as a whole in an impactful way, following the quadruple helix of innovation. Therefore, it enhances

cooperation, synergies and transdisciplinary collaboration, open to all Timorese people, including indigenous populations, women, youth and people with special needs, who can participate in many stages of the scientific process: from the design of the research question to data collection and volunteer mapping, data interpretation and analysis, through to publication and dissemination of results.

4.3 JUSTIFICATION FOR SETTING UP STI POLICY ACTIONS

STI are drivers for social, economic and sustainable development, which promote economic growth, and can address and alleviate societal challenges and challenges from climate change, among others. The critical importance of STI has been fully recognised and acknowledged from high-income countries to low-income countries, as emphasised in the SDGs, and shown by the increasing number of STI bodies, such as INCT, working to establish new STI legal frameworks, and drafting and implementing diverse, inclusive sets of new STI policies towards sustainability. The full set of STI input and implementation requires the appropriate (e-)infrastructures (physical, technological, scientific resources), and most importantly the capabilities of individuals, organisations and communities to use and absorb the process of technological and innovative development to own, diffuse and implement the changes required to achieve sustainable and inclusive growth.[28]

The STI initiatives are supported by the Timor-Leste Constitution (Article 59, point (4)): 'the State shall ensure the access of every citizen, in accordance to their abilities, to the highest levels of education, scientific research and artistic creativity'. However, in the Timor-Leste Strategic Development Plan 2011-2030, covering 19 years, science, technology and innovation are mentioned only briefly and no clear STI strategy had been laid out to support the plan's implementation. The setting up of INCT in September 2014 was a small first step towards adding STI capacity in Timor-Leste.

The HENP of January 2022 is a major step forward, which calls for an inclusive, open and sustainable STI strategy and a framework, making up for its lack in earlier national strategic plans. The policy document is broadly coherent with the framework presented in this report, underlining the utmost importance of having a national STI policy and strategy. The open science principles, discussed here, are considered from the start and embedded in the policy document. The independent work done and reported on here included a close examination of the map and the existing supporting structures in the STI ecosystem for each of the main policy objectives, and how they have been implemented so far in Timor-Leste.

4.3.1 PESTEL and SWOT analyses

Below, in **Table 1**, the political, economic, social, technological environmental and legal items are presented (PESTEL) and, in **Table 2**, the strengths, weaknesses, opportunities and threats (SWOT) analysis, both of which were collaboratively identified with the different key stakeholders.

28 See for example, UN, 2019; Rath, Amitav (2020).

Table 1 - PESTEL					
Political	**Economical**	**Social**	**Technological**	**Environmental**	**Legal**
Political and government instability, leading to change of policies Lack of political commitment Focus on STI policy as a priority to drive growth, supporting the Petroleum Fund, facilitating agriculture, tourism and other emergent sectors National Strategy did not envisage STI Evidence-based policy missing Research results are not always used to inform policymaking	Dedicated infrastructure for research must be part of the national budget Financial resources are limited, reliant on Petroleum Fund Research reports not always published and recorded Multiplier effect missing	Research communities to allow the knowledge to be retained (group of young people) System of recognition and rewards at university and research level needed Digital natives not being engaged Low STI skill sets with lack of programmers, inventors, thinkers Community and civil society, NGOs, national, international, and also private sector not active in STI	Infrastructure required to retain knowledge Poor internet connectivity and fibre optic cables Lack of open access journals, with international standards	SDG linked to environmental goals High risk of climate-related disasters	Laws to support the STI policy are missing Property rights law being drafted Zero patents have been filed (World Intellectual Property Organisation) Trademark registrations hit a peak in 2015, with 111 trademark registrations, and declined substantially since then, with 5 trademarks being registered in 2019 and 1 in 2020

Table 2 - SWOT analysis	
Strengths	**Weaknesses**
• Political willingness with the creation of INCT and a governance system in place to launch the STI agenda • Clear and well-designed higher education national policy, formulated and addressing STI and open science, embedded in the policy • Key actors are aligned to launch the National Digital Repository • Technological partners (telecom companies) are interested to support an open science approach, in particular the National Digital Repository	• Lack of STI agenda • Limited human capabilities to launch STI agenda and foster thriving STI communities • Indigenous, rural populations and women have limited access to STI and are not actively engaged • Lack of physical and (e-)infrastructure facilities to support STI activities at local, national and international levels • Lack of engagement with international research and innovation networks

Table 2 - SWOT analysis

Strengths	Weaknesses
• 18 HEIs • Some examples of open access journals already launched in Timor-Leste, such as the *Journal of Business and Management,* which is an international, online, open access and peer-reviewed journal that disseminates research results in the field of business and management and was launched in 2019 https://tljbm.org/jurnal/index.php/tljbm/issue/archive • Close connection to UNESCO, European Union, Association of Southeast Asian Nations, Southeast Asian Ministers of Education Organisation (SEAMEO)/ Regional Institute for Higher Education (RIHED) • Development (SEAMEO/RIHED), Comunidade dos Países de Língua Portuguesa (CPLP) • Associação das Universidades de Língua Portuguesa (AULP), Fórum de Gestão de Ensino Superior (FORGES) • Proximity to Australia, Indonesia, Singapore and Thailand. • 200 lecturers (January 2019)	• Lack of a legal deposit where works can be deposited • Very few open access journals launched in Timor-Leste • Low skills of the lecturers • Only 2 % of the lecturers have a doctorate (PhD) • Non-existent PhD and post-doctoral programmes, although foreseen in HENP • Low levels of business R&D and innovation • Low private-public partnerships • High price of data/connectivity • English language not sufficiently diffused to sustain productive international STI collaboration • Need to find additional revenue sources to avoid becoming over reliant on Petroleum Fund
Opportunities	**Threats**
• Submarine cable to connect Timor-Leste to Australia • Percentage of Petroleum Fund being redirected to support STI • Telecom companies' willingness to offer zero rating (as long as they all have the same access) • Become a reference for STI and in particular open STI policies in small island developing states • Engagement by different key stakeholders • Increased number of lecturers abroad, with around 100 persons working on PhDs • Human resources potential with young workforce • In future, research work in Timor-Leste will need to deposit the research work with INCT • Legal deposit with numbered publications (ISSNs and ISBNs) • Create a physical infrastructure, e.g. a STI incubation centre, to support STI in Timor-Leste • Renewable energies strategy and geographical position	• COVID-19 has posed more limitations to Timor-Leste by further reinforcing the triple isolation: island state, poor land and maritime connections (for instance, very few and scattered flights without clear timetables), poor and costly telecommunications connectivity • Climate change brings altered conditions and a rise in temperature (World Bank[29]) • Rising costs of goods and services due to current crisis, which fuelled the prices of petroleum and gas • Human resources with low STI capabilities • Brain drain

29 https://climateknowledgeportal.worldbank.org/country/Timor-Leste

The PESTEL and SWOT analyses allowed the experts to identify not only the main key constraints and limitations to STI in Timor-Leste, with a lack of laws to support STI policy implementation, very limited physical research facilities and low capabilities, but also the strengths and opportunities, with the creation of INCT to launch the STI agenda, the HENP, the submarine cable and Timor-Leste's close connection with relevant international key stakeholders.

4.4 FOUR ACTION PILLARS FOR TIMORESE STI POLICY

The STI policy elaborated here is rooted in the systems thinking discussed earlier on innovations, requiring the integration of elements and policy instruments from different policy fields, including science and technology, but also economic policy, entrepreneurship, regional and local development and planning, together with education, training and skills development policies. STI concerns and actions interact with specific sector policies, such as those on agriculture, energy, transport, health and others, including R&D programmes and regulations supporting innovation. This cross-cutting nature of STI policy makes it difficult to position within government[30], but the goal here is to build upon the initial Timorese institutional set-up to address STI policy domains, which are being addressed for the first time. This report makes use of the context and 'framework' conditions discussed above to formulate four action pillars for the STI policy domain for Timor-Leste.

From the general STI framework and the national environment analyses, the basic structure for **Timor-Leste STI policy action pillars** are developed to cohere with the HENP, which provides an excellent framework to sustain and support the STI policy and programme, with open science at its core.

The HENP has highlighted some of the **key principles** to be followed:

- Inter-ministerial and cross-sectoral coordination that leads to a quadruple helix engagement in STI;
- Long-term vision beyond the current government mandate;
- Fully aligned with SDGs and the Incheon Declaration;[31]
- Strong connections foreseen across international key stakeholders to promote STI, reinforcing an open STI;
- Acknowledgement of the need to engage internationally in open and more collaborative science and research;
- Promote distance learning/education, with the virtual campus (Campus Virtual) concept;

30 See UNCTAD, 2019. A FRAMEWORK for Science, Technology and Innovation Policy Reviews: Harnessing innovation for sustainable development; page 8. This leads some countries such as Finland and the Republic of Korea to place it at the Prime Ministerial level.

31 The Incheon Declaration was adopted on 21 May 2015 at the World Education Forum (WEF 2015) held in Incheon, Republic of Korea. The Incheon Declaration constitutes the commitment of the education community to Education 2030 and the 2030 Agenda for Sustainable Development, recognizing the important role of education as a main driver of development. http://uis.unesco.org/sites/default/files/documents/education-2030-incheon-framework-for-action-implementation-of-sdg4-2016-en_2.pdf

- Strong focus on research-based evidence and open data;
- Creation of a governance board between the key stakeholders involved and interested in promoting the development of STI;
- Revision of the legal framework to include, among others, distance learning, lecturer career advancement, researcher status;
- Create infrastructures, like the National Co-laboratory (Colaboratorio Nacional);
- Launch a national post-graduation programme for teachers and scientists;
- Define and approve the national science agenda;
- Promote federated open access repositories, supported on open source and connected to the national repository.

The Timorese STI policy actions rest on **4 pillars** (see **Table 3**) that are interrelated and form an integral part to further sustain the strategy and implementation axes defined in the HENP.

These 4 pillars are:

Table 3 - Four action Pillars for Timorese STI policy

Pillar 1: STI programme formulation	**Quadruple helix of innovation**
Pillar 2: National Digital Repository	
Pillar 3: Open science cloud (e-Colaboratorio Nacional)	
Pillar 4: Physical infrastructure	
Legal framework: policies and regulations to support, for instance, intellectual property rights with flexible/open copyright licences, to open the access to the legal deposit/National Repository	

The **quadruple helix** of innovation, with the involvement and engagement 'upstream' of government, academia, corporations and civil society under, for instance, citizen science, provides the model for the rapid and inclusive deployment and buy-in of the full Timorese system, an 'all hands-on deck' approach. The legal framework is recommended to be further extended following the areas already identified in the HENP.

4.4.1 Pillar 1: STI programme formulation

The following points are recommended to be considered when drafting more detailed elements of the Timor-Leste STI programme:

1. **Strengthen and optimise a vibrant INCT** with further governance structures for planning, budgeting, coordinating, managing and promoting scientific research, including open science (presented below in more detail).

a. Strengthening the INCT allows for preparing Timor-Leste to draft ongoing detailed STI policies, programmes and actions to support its scientific, research and innovation development, which is at a very incipient phase at this stage.

b. To achieve the critical and ambitious objectives and goals of the Timor-Leste STI programme, it is recommended to adopt a 3-tier structure:

i. A Governance Board, consisting of representatives from the INCT, Ministries and key stakeholders;

ii. An Advisory Board, consisting of experts from key national and international research and e-infrastructure communities who advise the INCT on the implementation of STI and the way forward;

iii. A Stakeholders Forum, giving voice to the wider community of users, service providers, industry, the public sector and citizens.

2. **Evaluation of the STI programme actions through research-based studies** that demonstrate with evidence whether the goals and impacts foreseen during the policy/programme design and implementation are indeed achieved. Ongoing modifications to programming requires the following:

   a. Training on research-based evidence;

   b. Creating open mechanisms to share the research and be able to build upon it;

   c. Creating a monitoring and evaluation system, supported by research-based evidence and with remote management, monitoring and validation (RMMV) systems.

3. **Gathering, processing and analysing basic data concerning national scientific potential**, which could be shared as open data (under the FAIR principles), to further allow for replicability of results and higher scientific and research quality. Currently there are several Ministries and the Petroleum Fund that have been collecting critical scientific data for decision-making at national level and supporting the growth of the (e-)infrastructure for scientific research, while addressing ongoing issues of storage and access and the support for 'open data' as a public good.

   a. Maintaining a proper balance between the various types of research (fundamental, applied, experimental development). During the interviews and from the questionnaires received, it was found that the research being done is mainly applied to agriculture and petroleum, but the required infrastructure (physical, technological and human for effectiveness) is missing. For increased effectiveness Physical National Co-Laboratory and Science Park incubators should be undertaken, with e-Colaboratorio supporting open science.

4. **Creating, supporting and sustaining a thriving creative scientific community** at national and international level to further foster STI and open science via the following:

   a. Training and capability building, which is a critical part of this;

   b. Sharing experiences with forums and an annual meeting with STI key stakeholders from the 4 quadrants of the helix;

   c. The research and scientific experiences gained are currently shared in an ad hoc manner, without a systematic system to support this type of communities of practice. It is also worth noting that novel (or not so novel) methods to drive creativity, such as human-centred design, are not well known and their implementation may require a change in mindsets, fostering team work and critical skills in international research.

5. **Assessing and promoting replicability and high-quality research in the various sectors**, where relevant (HEIs, government, private sector, businesses, non-profits, addressing the quadruple helix of innovation, which will be analysed later):

a. Open access: At national level, for instance, the research carried out abroad is currently not part of a national repository;

b. All research publications, funded by public budget, are to be deposited under a Creative Commons licence in the repository.

6. **Involving society in science, research and innovation, women, youth and the indigenous population**, through participatory and co-creation processes in research and innovation, 'Science with and for Society', reinforcing the need to bring participation and co-creation tools to research and scientific engagement in Timor-Leste, with participatory, co-creation and knowledge events, such as innovation and science days.

7. **Involving local government in science, research and innovation**, through processes similar to those above.

8. **Responsible research and innovation (RRI) systems**, connecting different aspects of the relationship between R&I and society: public engagement, open access and data, gender equality, science education, citizen science, ethics and governance[32].

9. **Identifying, addressing and raising awareness towards new risks and ethical dilemmas created by science and technology**, by taking proactive measures, such as addressing plagiarism, 'fake news' or the selling of products that impact health and the environment. The KOMBATE HOAX campaign that was launched addresses this need.

10. **Set up a national aggregator (directory) for open access journals.** It is relevant for researchers, teachers, students and innovators to have an overview of journals that are freely available. This can be through the Directory of Open Access Journals.[33] Relevant content (articles, journals) can be part of the National Digital Repository (see **Chapter 5**) to prevent individuals needing to go online via the (expensive) internet.

4.4.1.1 OPEN SCIENCE

Open science has been expanded upon here, following the emphasis in HENP that it should be considered right from the programme strategy design as a public good for Timor-Leste. Below, several recommendations to open science are presented, which were permeated in the programme design suggested.

Openness has been described in different ways. Morais (2013) defines openness as 'a Public Good, that must be promoted by the governments, public institutions to make available knowledge and research, at the lowest possible cost, preferably "at no more than the marginal cost of dissemination" (OECD, 2007), increasing knowledge generation and innovation'.

Open science provides new ways in which science, research and innovation are undertaken. UNESCO, in 2021, drafted a recommendation on open science where a working definition was presented, as:

1. 'making multilingual scientific knowledge openly available, accessible and reusable for everyone,

2. increased scientific collaborations and sharing of information for the benefits of science and society, and

3. open processes of scientific knowledge creation, evaluation and communication to societal actors beyond the traditional scientific community'.

32 https://rri-tools.eu/
33 https://doaj.org/

It comprises all the scientific disciplines and aspects of scholarly practices, and is expected to provide greater efficiency and productivity, more transparency and a better response to interdisciplinary research needs (LERU, 2018[34]), as well as to the requirement for building resilient and quickly adaptive scientific and research systems to needs such as those generated by COVID-19 (OECD, 2020). In the Pascal Lamy report on the Interim Evaluation of the Horizon 2020 Programme, it is stated: 'Europe must embrace the transformative power of science, allowing for a faster circulation of increasing amounts of knowledge, and seize the potential of open innovation to trigger faster and fair growth, building a knowledge economy that is open to the world' (LAB-FAB-APP, 2017, p. 8[35]).

UNESCO (2021) presents 5 key pillars for open science:

1. Open scientific knowledge
2. Open science infrastructures
3. Science communication
4. Open engagement of societal actors
5. Open dialogue with other knowledge systems

The European Commission expands it to 8 pillars for open science:

- Scholarly communication (open access)
- EOSC (European open science cloud)
- FAIR data
- Citizen science
- Rewards & recognition
- Skills & training
- New generation metrics
- Research integrity & reproducibility of scientific results to regulatory instruments, such as laws and regulations.

Timor-Leste joined the World Intellectual Property Organisation in 2017 and is currently drafting the intellectual property rights law, which will be promulgated by the end of 2022.

4.4.2 Pillar 2: Timor-Leste National Digital Repository

Digital repositories have developed with the technological developments in computers and related digital technologies since the late 1980s, and take advantage of digital technologies to create an online environment for scientific publications, but also become increasingly important for research data, software and other research outputs to create a knowledge hub that is useful for students, researchers, government policymakers, social groups, publishers and libraries, and can form a core building block of national knowledge and research infrastructure. In Timor-Leste, it is planned to provide access to scientific publications and can include, among others, peer-reviewed journal articles and books, research reports and conference papers, from Timor-Leste researchers or about Timor-Leste, or relevant to Timorese students and researchers, all hosted in the National Digital Repository.

Targets:

- To make all scientific publication output open access, especially those that are generated using public funds;
- To ensure that society and the economic sectors can reuse all scholarly output;

34 LERU, 2018; https://www.leru.org/files/Implementing-open-science.pdf
35 https://op.europa.eu/en/publication-detail/-/publication/ffbe0115-6cfc-11e7-b2f2-01aa75ed71a1/language-en/format-PDF/source-77975731

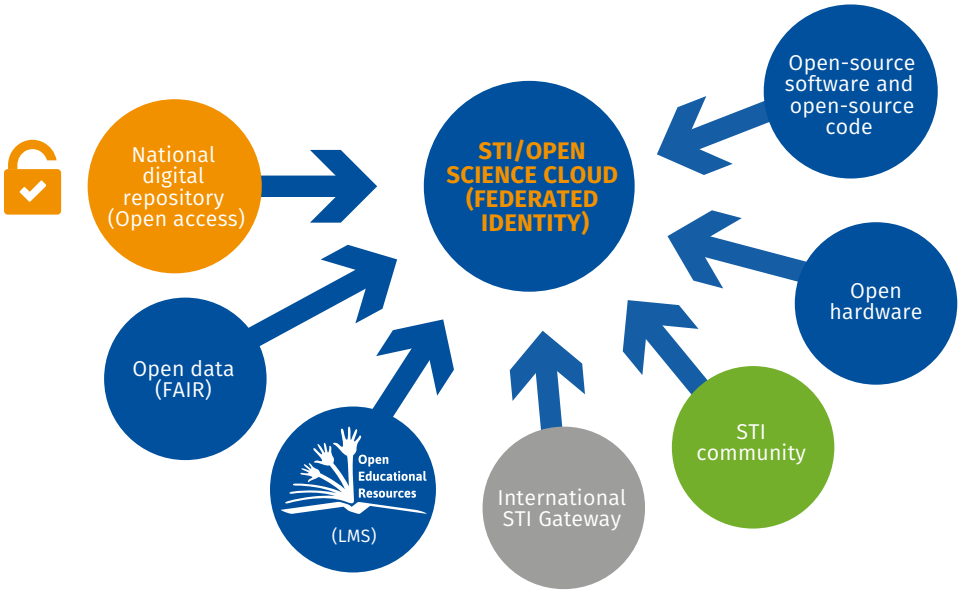
- To be free of charge;
- To be in the public domain or under copyright and licensed under an open/ flexible licence;
- To maintain a high quality;
- To ensure research integrity;
- To make replicability not only possible, but also desirable.

The National Digital Repository will be discussed in detail in **Chapter 5**.

4.4.3 Pillar 3: Open science cloud (e-Colaboratorio Nacional)

An open science cloud is a federated ecosystem (**figure 3**), allowing the separate systems to connect and to be made available to all partners in the quadruple helix. Besides the National Digital Repository for publications, it can encompass the sharing of research data, educational resources, hard- and software, etc. As it is a federated system, it allows scaling from the National Digital Repository and building from there.

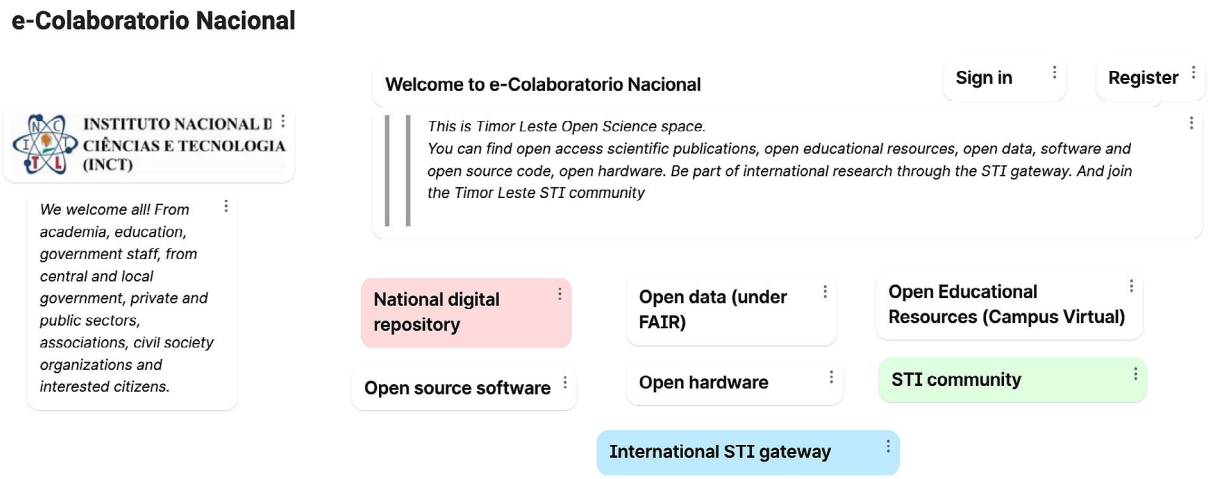
Figure 3 **e-Colaboratorio Nacional (Open science cloud)**



Source: Authors' own elaboration, after co-creation with INCT, national team and key stakeholders.

The e-Colaboratorio Nacional is 'an environment where research resources (hardware, software and content) can be readily shared and accessed, to promote better and more effective research; such an environment integrates hard-, soft- and middle-ware components, networks, data repositories, and all sorts of support enabling virtual research collaborations to flourish globally' (see **Figure 4**). Some of the resources available may include knowledge-based resources including Timor-Leste's NDR, open bibliometrics and scientometrics systems for assessing and analysing scientific domains, open computational and data manipulation service infrastructures that enable collaborative and multidisciplinary data analysis and digital infrastructures, which are needed to support open science and serve the needs of different communities.

Figure 4 **e-Colaboratorio Nacional (Open science cloud) website example (user experience).**



Source: Authors' own elaboration, after co-creation with INCT, national team and key stakeholders

The following key components could be considered and scaled accordingly, as shown above:

Open research data, available in a timely and user-friendly, human- and machine-readable and actionable format, in accordance with the principles of good data governance and stewardship, notably the FAIR principles, and supported by regular curation and maintenance. Data should be 'as open as possible, as closed as necessary'.

Targets:

- Make all research data open, especially those that are generated using public funds;
- Support and guide the generation of rich, standardised data and metadata that follows the FAIR principles;
- The National Digital Repository becomes the data ecosystem, including sensitive and confidential data, in cooperation with stakeholders.

It will consist of a data repository, and metadata profiles that connect to international standards (can depend on a science domain, but should have a common denominator);

- Ensure that society and the economic sectors can also reuse all data outputs, when applicable;
- Data usage is free of charge;
- Data is held in the public domain or under copyright and licensed under an open/flexible licence;
- High quality is maintained;
- Maintain research integrity;
- Replicability is not only possible, but also desired.

Open educational resources (OER) are 'teaching, learning and research resources that reside in the public domain or have been released under an intellectual property licence that permits their free use and re-purposing by others. Open educational resources include full courses, course materials, modules, textbooks, streaming videos, tests, software

and any other tools, materials or techniques used to support access to knowledge.'[36]

Targets:

- Make all full-time courses, course materials, modules, textbooks, streaming videos, tests, software and any other tools, materials or techniques used to support access to knowledge, especially those that are generated using public funds, open in the National Digital Repository;
- Resources are held in the public domain or under copyright and licenced under an open/flexible licence;
- Ensure that educational institutions, society and economic sectors can also reuse all content outputs;
- Resources must be free of charge;
- High quality is maintained;
- Develop a virtual campus (e-learning and blended learning).

Open-source software and open-source code 'generally include software whose source code is made publicly available, in a timely and user-friendly manner, in human- and machine-readable and modifiable format, under an open license that grants others the right to use, access, modify, expand, study, create derivative works and share the software and its source code, design or blueprint' (UNESCO 2021). Currently, the only open-source software available is internationally developed. The open-source software would be mirrored at national level, thus allowing for shorter download times and reduced costs.

Targets:

- Make open-source software and source codes open, especially those that are generated using public funds;
- Open-source software and source codes are held in the public domain or under copyright and licenced under an open/flexible license, such as GNU;
- Mirror, with permission, open-source software and source codes developed internationally, to diminish the telecommunications costs and broadband use;
- The National Digital Repository holds the open source and source code of the system made in Timor-Leste, respecting IPR when relevant;
- Ensure that society and the economic sectors can also download the open source and source code, when applicable;
- Open source and source code remain free of charge;
- High quality is maintained;
- Maintain research integrity.

The **open hardware database** 'includes the design specifications of a physical object which are licensed in such a way that said object can be studied, modified, created and distributed by anyone, providing as many people as possible with the ability to construct, remix and share their knowledge of hardware design and function' (UNESCO, 2021).

36 Hewlett Foundation, 2013; https://hewlett.org/wp-content/uploads/2016/08/OER%20White%20Paper%20Nov%2022%202013%20Final_0.pdf

Targets:

- Make open hardware and designs open, especially those that are generated using public funds;
- Open hardware databases are held in the public domain or under copyright and licensed under an open/flexible licence, such as GNU;
- Mirror, with permission, open hardware and designs developed internationally, to diminish the telecommunications costs and broadband use;
- The National Digital Repository holds the open hardware system made in Timor-Leste, respecting IPR when relevant;
- Ensure that society and the economic sectors can also download the open source and source code, when applicable;
- Open hardware database remains free of charge;
- High quality is maintained;
- Maintain research integrity;
- Replicability is possible.

The **international STI gateway** can be fostered and quickly deployed via National, Regional and Pan-Regional Research and Education Networks (NREN, RREN), which are drivers of these type of e-infrastructures. The INCT is positioned to become a driver for Timor-Leste's open science cloud, and a regional reference. It is highly recommended that the INCT creates strong partnerships with the RREN to profit the most from the different international research e-infrastructures already available, such as eduGAIN, eduroam[37].

Targets:

- Identify key national and international areas and partnerships;
- Engage the quadruple helix of innovation;
- Maintain the gateway free of charge;
- High quality is maintained;
- Maintain research integrity
- Replicability is possible.

A strong **STI community**, involving the 4 helixes, is critical for a thriving and innovative STI ecosystem in Timor-Leste. This community(ies) can be fostered through the existence of online communities (whether through online engagement forums or social media) and hackathons. This thriving community can be created by mapping the researchers, scientists, inventors and innovators in Timor-Leste and developing a database, following strong ethical and data privacy policies[38].

Targets:

- Data privacy policies in place;
- Create a database of STI researchers;
- Support a thriving community through online and face-to-face engagements;
- Provide dissemination and communication on STI, including open science, across the 4 helixes;
- Disseminate open research positions at national and international levels;
- Community must be free of charge;
- RRI must be applied.

37 Edugain and Eduroam are tools to safely connect to university systems for education and to login automatically to a safe wifi environment. https://edugain.org/; https://www.eduroam.nl/

38 https://ddc.dk/tools/toolkit-the-digital-ethics-compass/

4.4.4 Pillar 4: Physical infrastructures

The physical infrastructures include laboratories, research facilities, major scientific equipment and research instruments that can be shared among the different key stakeholders, with 'open labs' and 'living labs'[39] for instance. Many countries have a **roadmap** of such infrastructures to provide an overview to potential users and to prevent overlap or doubling of expensive equipment. This can be repeated at international level, such as the European Roadmap for Research Infrastructures (ESFRI, 2021) .

Such infrastructures can also accommodate **training and events areas**, with sleeping quarters where those from further afield can stay, and innovation **incubators**, where researchers and scientists can work with companies or create their own companies, providing another channel for innovations following international best practices, such as the business model canvas and human-centred design for defining the challenges being addressed, testing the different assumptions with the quadruple helix of innovation, prototyping and scaling the solutions. Special attention should be provided to the needs for **internationalisation** and maximising partnerships.

It is also possible to consider hosting the INCT's Legal Deposit and the confluence of the STI ecosystem through collaborative areas for the quadruple helix of innovation, such as a science park with incubation, companies, training spaces, and areas where the researchers and scientists can stay while doing research.

It is recommended to launch a feasibility and viability study to identify the types of STI infrastructures that would have maximum impact and sustainability in Timor-Leste, together with costs, thus no targets are presented for this pillar.

4.5 OPERATIONALISATION OF TIMORESE STI POLICY ACTIONS

The operationalistion of the STI policy actions require a framework with indicators, expected outputs and outcomes, identifying best practices with associated tools, potential international partnerships and resources for each of the pillars (see **Table 4**).

Table 4 - Operationalisation framework

Pillar 1	**STI programme formulation**
Indicators	Governance Number of stakeholders involved from the quadruple helix, disaggregated by gender, age, rural/urban, special needs Number of evidence-based evaluation studies and applied results Open data sets made available Quantity of research carried out per type Number of researchers/scientists involved

39 https://enoll.org/
40 European Strategy Forum for Research Infrastructures; https://roadmap2021.esfri.eu/
41 https://www.businessmodelsinc.com/about-bmi/tools/business-model-canvas/

Table 4 - Operationalisation framework	
Pillar 1	**STI programme formulation**
Outputs	STI national policy
Best practices	**Governance and structure** **Portugal: Fundação para a Ciência e a Tecnologia (FCT)**, founded in 1997, is the Portuguese public agency that supports science, technology and innovation, in all scientific domains. It is under the responsibility of the Ministry for Science, Technology and Higher Education. Fundação para a Computação Científica Nacional (FCCN), the Portuguese NREN, is part of the FCT, thus allowing for a holistic STI strategy and implementation. https://www.fct.pt/ **STI policy** **India**: setting up the STI policy, through participatory, bottom-up approaches. https://thesciencepolicyforum.org/initiatives/science-technology-and-innovation-policy-stip-2020/ https://www.psa.gov.in/stip **Chile:** the design of STI policy is supported in participatory approaches with 4 axes identified. https://www.minciencia.gob.cl/politicactci/index.html **Research-based evidence** **USA JPAL:** Abdul Latif Jameel Poverty Action Lab (JPAL) is one of the leading organisations in research-based evidence for policymaking with training being carried out around the world. They also have open online courses available that can be attended at low or no cost. https://www.povertyactionlab.org/ https://www.povertyactionlab.org/page/online-courses
Potential partnerships	**National** **INCT/MESCC** Quadruple helix with involvement and engagement of all key stakeholders. As shown in the key stakeholder mapping there is a lack of involvement of CSOs. Ministries and local government should be involved upstream as recommended. **International:** **JPAL**

Pillar 2	**Timor-Leste National Digital Repository**
Indicators	Number of open access publications available Number of scientific works registered Number of ISBNs/ISSNs Number of DOIs
Outputs	National Digital Repository Legal deposit

Table 4 - Operationalisation framework	
Pillar 2	**Timor-Leste National Digital Repository**
Best practices	Best practices for the digital repository are detailed in Chapter 5, while best practice examples for **Legal deposit** are presented below. **Canada:** Library and Archives Canada (LAC): Canadian publishers and producers help LAC to build the national collection. Through the legal deposit programme, LAC collects materials created in Canada and intended for sale or public distribution. The material is made available for the public to consult and to preserve it for future generations. They present all the different tools to be used to set up the legal deposit, which was begun with the NDR rapid prototype. https://www.bac-lac.gc.ca/eng/services/legal-deposit/Pages/legal-deposit.aspx **Portugal:** FCT Historical Archive of Science and Technology was established in 2011, as an outcome from the project that treated the collections that have come into the custody of the FCT over the years and making them available to the scientific community and the public. It presents in detail the different archival phases. https://www.fct.pt/arquivo/ https://act.fct.pt/ **Quality criteria of research output** **USA:** Biomedical Science and Research Journal provides an example of high-quality guidelines for editors, authors and reviewers. https://biomedgrid.com/index.php **Canada:** The International Review of Research in Open and Distributed Learning (IRRODL) is a refereed open access journal, based at Athabasca University. It was one of the first open access research journals to be launched in 2000 and provides clear guidelines for authors, reviewers, librarians and readers. http://www.irrodl.org/index.php/irrodl **PLOS** is a non-profit, open access publisher, empowering researchers to accelerate progress in science and medicine by leading a transformation in research communication, supported in open science. The guidelines to publish in the different journals are clearly stated and can be used as a benchmark for the NDR. https://plos.org/publish/
Potential partnerships	**National:** INCT/MESCC Quadruple helix with involvement and engagement of all key stakeholders. **International:** OpenAIRE is a non-profit partnership, established in 2018 as a legal entity, to ensure a permanent open scholarly communication infrastructure to support European research. https://www.openaire.eu/ **Science Gateway** is a website for biomedical research with pubmed search, journals, textbooks and database. https://www.sciencegateway.org/index.html **Public Knowledge project (PKP)** is a multi-university initiative developing (free) open-source software and conducting research to improve the quality and reach of scholarly publishing. https://pkp.sfu.ca/ **PLOS** https://plos.org

Table 4 - Operationalisation framework	
Pillar 3	**Open science cloud (e-Colaboratorio Nacional)**
Indicators	Open data sets made available Number of open software source codes available and hardware Number of downloads Number of research carried out per type and country (disaggregated data) Number of researchers/scientists registered Number of partnerships established Number of international projects Number of OERs available Number of courses available Number of participants
Outputs	e-Colaboratorio Nacional
Best practices	**European Open Science Cloud (EOSC) Portal** is part of the expected 'federating core' services contributing to the implementation of the 'Access and interface' action line. https://eosc-portal.eu/
Potential partnerships	**National:** INCT/MESCC Quadruple helix with involvement and engagement of all key stakeholders. **International:** **Pan-European:** GÉANT is the collaboration of European National Research and Education Networks (NRENs). Together they deliver an information ecosystem of infrastructure and services to advance research, education, and innovation on a global scale. https://geant.org/ **EOSC** https://eosc-portal.eu/ **Pan-Asian: APAN Asian Pacific Advanced Network** is the international partnership of the NRENs across the region. https://apan.net/ **Pan-Latin America and Caribbean: RedCLARA** aims to be recognised as a key player in strengthening science and technology in Latin America, ensuring that 60 % of the end users of the NRENs use applications and collaboration platforms federated across RedCLARA. https://www.redclara.net/index.php/en/ **Australia: AARNET's** high-performing network and services are purpose-built to support collaboration, knowledge sharing and innovation in Australia. https://www.aarnet.edu.au/ **Germany: Siemens Stiftung (Foundation)** has an impressive library of open educational resources for **STEM education**. https://www.siemens-stiftung.org/ https://www.siemens-stiftung.org/en/projects/experimento/ **Germany: atingi.org** is a flagship project for the German Government to provide inclusive, accessible, relevant, safe and secure digital content for all. It has an enormous collection of OER, as courses, in very different knowledge areas. https://www.atingi.org/

Table 4 - Operationalisation framework	
Potential partnerships	**United Kingdom:** The Raspberry Pi Foundation (RPF) is a charity that works to put the power of computing and digital making into the hands of people all over the world. It had an impressive repository of OER about computing and digital technologies for education **(focus on STEM Education)**, work and research to solve problems that matter to students, citizens, teachers and researchers (a data-driven organisation). https://www.raspberrypi.org
Pillar 4	**STI physical infrastructures**
Indicators	Number of research laboratories created, disaggregated by type, sector Number of incubators
Outputs	National research and incubator centres Research centres
Best practices	**Switzerland:** CERN Science Gateway, a new educational and outreach facility of about 7 000 m2, will be a unique attraction in the heart of Europe, bringing visitors up close to the science and innovation at CERN. It is to be launched in 2023. https://cernandsocietyfoundation.cern/projects/science-gateway **Portugal:** Taguspark is the largest science and technology park in Lisbon, where academia, research and national and international companies connected to emerging technologies coexist. https://www.taguspark.pt/en/
Potential partnerships	**National:** INCT/MESCC Quadruple helix with the involvement and engagement of all key stakeholders. **International:** **Potential funding partners for this pillar and other pillars:** **European Commission** https://ec.europa.eu/international-partnerships/where-we-work/Timor-Leste_en **Germany:** KfW (German development bank) https://www.kfw.de/About-KfW/ **Asian Development Bank** https://www.adb.org/ All the funds available are listed here in the following link: https://www.adb.org/what-we-do/funds

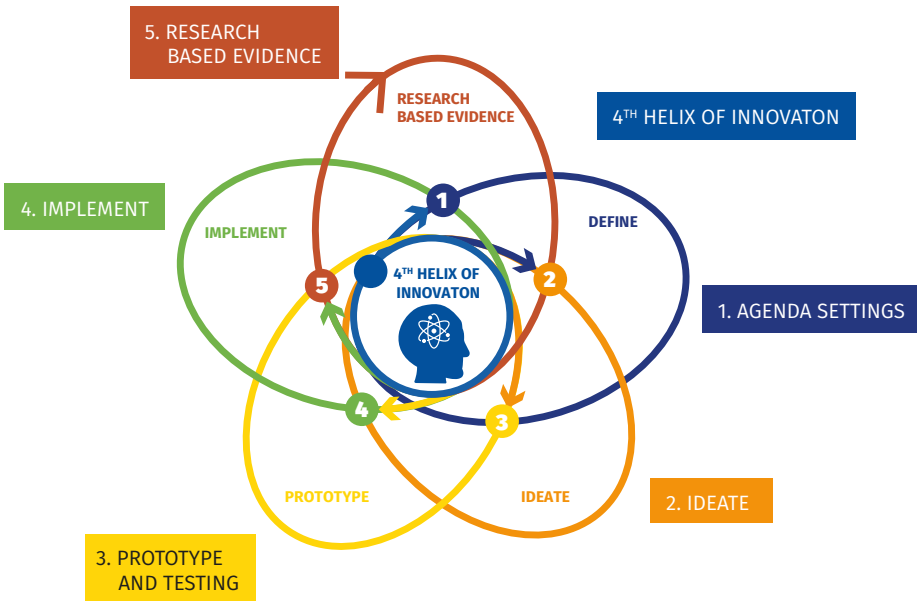
The implementation will require a strong, upstream engagement of the different key stakeholders, through the establishment of critical partnerships among government, academia, and research and industry, for joint research, and can take several forms (see **Table 5** for key stakeholders' – national and international – engagement through partnerships and other instruments).

Table 5 - Key stakeholders	
Key stakeholders (national and international) engagement through partnerships and other instruments	
Indicators	Number of partnerships established
Outputs	Increase in STI activities in Timor-Leste with impact in civil society
Best practices	European Commission: due to the funding framework programmes implementation over the years, the European Commission is a great source of instruments and templates for setting up partnerships. **Public private partnership (PPP)** under Horizon 2020 provides a comprehensive look at how to set up PPPs between the EU, academia and research and industry for joint research. This type of partnership may provide an excellent framework for Timor-Leste. https://www.era-learn.eu/partnerships-in-a-nutshell/type-of-networks/partnerships-under-horizon-2020/public-private-partnerships-other-era-relevant-partnerships **Memorandums of Understanding** are instruments that enable the quick establishment of strategic and work frameworks between different types of institutions, along with non-disclosure agreements to protect IPR. https://intellectual-property-helpdesk.ec.europa.eu/regional-helpdesks/european-ip-helpdesk/europe-useful-documents_en

4.5.1 Operationalisation of STI policy

Figure 5 below presents the structure for the operationalisation of the four pillars, following a human-centred design-based approach, starting with agenda setting, then ideation, prototyping and testing, decision-making for scalability and sustainability, implementation, and finally research-based evaluation for constant improvement and impact.

Figure 5 **STI policy actions approach**



Source: Authors' adaptation from Gachago et al., atingi.org, under a Creative Commons licence.

It is recommended that an iterative approach will allow the Timor-Leste STI programme to evolve and quickly adapt to the challenges, developing a resilient capacity.

Furthermore, the operationalistion approach starts by identifying the key stakeholders, processes, methods, and instruments to provide a coherent working operationalisation, as presented in **Table 6** below.

Table 6 - Operationalisation of the Timorese STI policy actions approach

Timor-Leste STI policy actions	Agenda setting/ feasibility study	Design and testing	Decision-making for scalability and sustainability	Implementation	Evaluation / research-based evidence
Key stakeholders	INCT Government Quadruple helix of innovation PSF	INCT Quadruple helix of innovation	INCT Government Quadruple helix of innovation	INCT Government Quadruple helix of innovation	INCT Government Quadruple helix of innovation
Processes	Independent feasibility study	Design of programme options within INCT and government Governance based on study	INCT and government decide on priorities	Programme is iteratively implemented and continuously monitored	Research-based evidence
Methods	Ideation, co-creation and participatory approaches	Minimum viable repository testing	Development for scalability Training	Dissemination Exploitation of research results	
Instruments	Feasibility study	Legal framework: laws, decrees, regulations Contracts National and international agreements and partnerships	Organisational chart, procedures and methodologies	Contracts National and international agreements and partnerships	Research-based evidence

4.5.2 Building STI expertise

As previously stated in the PESTEL and SWOT analyses, there is a lack of highly qualified STI skills in Timor-Leste. This needs to be urgently addressed by quickly engaging strategic partnerships that will allow the country to 'leapfrog' towards 2021's STI skills. The use of hybrid learning approaches and participation in international STI networks can accelerate this transformation to a shorter period of time, creating a vibrant STI community. This will require a strong commitment from all key stakeholders, especially from the government, in order to sustain the INCT implementing its mission and strategy, with the involvement of all key stakeholders.

Based on the framework presented above along with the three pillars of STI policy actions previously identified (the required expertise for the NDR is presented in detail in **Chapter 5**), the following expertise will be required, among others:

- Scientists and researchers in emergent technologies, such as AI, IoT and drones applied in agriculture and other key economic areas, biotechnology, etc.;
- Open science;
- Open data;
- Open access;
- IPR in research and innovation;
- Agile project management;
- Co-creation and participatory approaches;
- Scientific dissemination and communication;
- Development of partnerships;
- Exploitation of results;
- Developers;
- Telecommunication network.

Special consideration should be given to the career paths of scientists, researchers and academics as foreseen in HENP, allowing for novel ways of recognition and rewards, following the DORA Declaration[42], for instance. These career pathways should be analysed in detail during the STI programme formulation to provide credible recognition, aligned with international standards allowing for recognition at national and international levels. It needs to be noted that academic careers should allow for different specialisations and alignments with emerging technologies, where areas of knowledge and practice have been evolving at an exponential speed and so require periodic reviews.

4.5.3 Training/capability developments

The following training and capability developments have been identified during interviews with the relevant key stakeholders, questionnaires and workshops, and through general observation:

- General research skills;
- Skills and expertise necessary for open access publishing and utilising open access repositories;
- Skills and expertise regarding open data and particularly data management (analysis, use and reuse of data), metadata and data dissemination (sharing and granting access to data);
- STI and open science skills enabling professional research conduct, which include research management skills, research integrity and ethics skills, and IPR and legal skills;
- Skills and expertise resulting from a general and broad concept of citizen science, where researchers interact with the general public (either directly in collaboration projects or indirectly

42 https://sfdora.org/

through scholarly communication) to enhance the impact of science, research and innovation in society;

- Skills developing innovative and creative approaches to STI, such as human-centred design and design thinking;
- Skills in project management, agile approaches and SCRUM (a framework for Agile software development);
- Skills in research results exploitation.

4.5.4 Timeline

The timeline in the roadmap encompasses both feasibility studies, so as to provide a full view of the implementation of both components, since the National Digital Repository is the first stepping stone for the STI policy actions deployment (see **Table 7**).

Table 7 - Timeline

Timor-Leste STI policy actions	Agenda setting/ feasibility study	Design and testing	Decision-making for scalability and sustainability	Implementation	Monitoring and evaluation / Research-based evidence
Pillar 1: STI programme formulation	April 2022	December 2022	April 2023	September 2023	September 2025
Pillar 2: Timor-Leste National Digital Repository	April 2022	September 2022	December 2022	January 2023	January 2023 - December 2025
Pillar 3: Open science cloud (e-Colaboratorio Nacional) supported by Timor-Leste National Digital Repository	April 2022	January 2023	April 2023	June 2023 - December 2025	January 2023 - December 2025
Pillar 4: STI physical infrastructure / research labs creation support	April 2022	January 2023 Feasibility study	May 2023	September 2023 - December 2028	May 2023 - December 2030
Open engagement of societal actors, citizen science and other knowledge systems	April 2022	Ongoing	Ongoing	Ongoing	Ongoing

Table 7 - Timeline					
Timor-Leste STI policy actions	**Agenda setting/ feasibility study**	**Design and testing**	**Decision-making for scalability and sustainability**	**Implementation**	**Monitoring and evaluation / Research-based evidence**
Legal frameworks	April 2022		December 2022		
Creating and fostering partnerships	April 2022	Ongoing	Ongoing	Ongoing	Ongoing
Expertise identified and engaged	April 2022	Ongoing	Ongoing	Ongoing	Ongoing
Training / Building capabilities	April 2022	Ongoing training needs identified Training programme defined and implemented	Ongoing training needs identified Training programme defined and implemented	Ongoing training needs identified Training programme defined and implemented	Ongoing monitoring and evaluation

4.6 CREATING PARTNERSHIPS

The SDG 17 statement: 'Strengthen the means of implementation and revitalize the global partnership for sustainable development' clearly states the importance of establishing 'multi-stakeholder initiatives voluntarily undertaken by governments, intergovernmental organisations, major groups and other stakeholders, efforts which are contributing to the implementation of inter-governmentally agreed development goals and commitments such as STI, and endorsing partnerships, building on the experience, resources and capabilities of the partners to drive STI and open science.

Partnerships can be further explored through open networks. Open networks create large opportunities for enhancing knowledge and building capacities. But we also need to be vigilant in their design and operations to keep out false and misleading information – a growing problem in social networks used by both the public and scientific networks.

On 18 September 2020, the Secretary of State for Communications launched the National Campaign KOMBATE HOAX (combating rumours and false information). This national campaign aimed to raise public awareness of the negative impacts of rumours and false information, and to identify ways to reduce their circulation on social networks, namely by rejecting the sharing of false information, thus avoiding its dissemination by the population.

4.6.1 Co-creation and participatory approaches to foster partnerships and networks

Over the last decades, advances in technology have opened up unique opportunities for governments to rethink the way they design and deliver services and policies, including STI policies.

In the light of rapid digital transformation, citizen-centred approaches to innovation gained more and more relevance – and also in the public, HEI and R&D sectors. While private tech companies, such as Apple Inc., Google and SAP, have been using human-centred approaches to improve their products and services, HEIs and research centres are only just discovering their benefits.

The advantage of these approaches is that they offer efficient ways to ensure that innovative solutions meet the needs of the users, especially in applied and experimental development research. These co-creation and participatory approaches[43] allow:

- engaging the key stakeholders from a very early stage, getting their ownership and buy-in, with critical insights based on their wants and needs;
- creating practical, fast and low-cost results, with rapid prototypes that allow visualising and agreeing on the most valuable features. The National Digital Repository rapid prototype is a good example of the use of available cloud-based applications to co-create it with key stakeholders very quickly;
- fostering experimentation and testing culture;
- promoting the embracing of failure and iteration for optimum results;
- combining technical feasibility and economic viability with the human desirability needed for the development of holistic solutions;
- approaching problems from a human perspective, with the objective of designing innovative and desirable products, services or experiences.

The following approaches are recommended to foster the engagement of the quadruple helix in STI:

a. **Engagement throughout the STI process:** The quadruple helix of innovation should be considered throughout the overall stages of STI, from policy design, implementation and evaluation to the scientific, research and innovation projects, work design, prototyping, testing, implementation and evaluation.

b. **Creation and sustaining of citizen science networks (physical and virtual):** Citizen science with the involvement of civil society, which can range from students with STEM education to CSOs or engaged citizens, can be powerful tools for transformation. These networks can support research in areas so diversified as early earthquake/tsunami detection and warning, ornithology, etc.

43 https://www.designkit.org/ for Human Centered Design; https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5b41f4f65&appId=PPGMS for organising co-creation workshops at policy level; https://www.opengovpartnership.org/wp-content/uploads/2018/05/OGP-Participation-Co-Creation-Toolkit_ARCHIVE.pdf for organising co-creation workshops at PPP level.

c. **Hackathons to 'wicked' challenges:** Inolving the quadruple helix allows for very different points of view, including wicked and adaptive challenges that require adaptation and change. Digital transformation in local government is an example of the importance of this collaboration as all the key stakeholders will play different roles in the system. Earthquake early warnings, for instance, are critical for Timor. CSOs, civil society through citizen science and private sectors can play a key role in research, from drones to the installation of detectors (for instance, the use of Raspberry Pi in these settings is a well known example).

d. **Dissemination and communication:** International STI collaboration, open science, citizen science and co-creation are not only novel ways of doing research and innovation, but also require different mindsets to be implemented. Podcasts, science on television, use of social media and design dash events can be great ways to increase dissemination and allow the role of STI to become part of Timor-Leste's social-economic fabric.

4.6.2 Open science legal frameworks

The open science legal frameworks vary between countries and their own and international arrangements. Therefore, the legal frameworks presented here are generic based on the experience of the team of experts implementing them across the world. The main legal frameworks to be considered include:

- the right to information, which is foreseen in Timor-Leste's Constitution (2002) under Article 40: Freedom of expression and information;
- data protection, which is partially covered by Article 36: the right to honour and privacy in Timor-Leste's Constitution (2002). The General Data Protection Regulation (GDPR), which entered into effect in 2018 for all European Union Member States, is an excellent benchmark when scientists process personal data for research purposes. The GDPR created new obligations for researchers who must put in place appropriate safeguards;
- open data and public sector information where 'open by default' should be considered as part of public goods and is normative;
- copyright law to include flexible copyright licences in digital environment, sui generis database right (SGDR)[44].

44 For further guidance: https://www.wipo.int/copyright/en/activities/copyright_licensing.html

4.7 OVERALL BUDGET TARGETS

An aspirational rule of thumb allocation for STI initiatives in developing countries has been to aim for 1 % of the national output (GDP). In Timor-Leste, government spending has amounted to almost 75 % of total national economic output (GDP) in recent years, which is unusually high. Some years, the budget is larger than the national GDP. This has been sustained because of the Petroleum Fund, and yet, budget deficits have averaged at 25 % of GDP.

The Timor-Leste Government approved a total budget of USD 1.675 billion for the 2022 fiscal year (reduced from USD 1.895 billion, by 17 %, compared with 2021). Its GDP for 2022 may be estimated to be close to its budget, but possibly lower, if the COVID-related effects on the economy persist.

Any and all new allocations must be made by keeping in mind the many alternate uses that are possible for budget resources. Second, allocations for STI have to take into account the nascent stages of STI activities supported in the country. Third, the initial size of the budget allocated is less important than a consistent and long-term vision and actions, supported by the government and all stakeholders, as has been emphasised in the new national higher education policy document of 2022.

A 1 % target for government investment would allocate approximately between USD 15-20 million annually for STI initiatives. It is suggested here that, initially for the first year and for a period of 5 years, the allocation for STI could be targeted at 0.25 % of GDP, for a sum of USD 4 million. This figure can be supplemented by additional grants available from external partners, including the EU.

The INCT must build upon the current strategy document of April 2022 and prepare short and medium-term work plans, within the above resource envelope, for further discussions by the stakeholders, and guidance and subsequent approvals by the government.

Unlocking the potential for STI requires additional investments, but not only further financial resources: it is necessary to develop and put in place the right policy frameworks for the unique conditions of Timor-Leste.

5 The National Digital Repository

5.1 DEFINING A REPOSITORY

The world is long familiar with museums and libraries storing and making accessible cultural treasures, artistic and historical materials, and scientific, technical and medical publications, keeping them secure for the future and making them accessible to the public for enhancing their knowledge. While museums have focused on more unique and critical historical artefacts, the traditional libraries were based on providing access to books in each city and municipality, and archives for collecting and managing groups of works, with a focus on a specific context for the overall collection[45].

For many years this has been referred to as artefacts, books and other tangible outputs. With the development of the internet as a global platform and digitisation, the way to find, access and use information has drastically changed. Information became available for every household via an internet connection, as long as it was searchable and access was granted.

5.1.1 Setting up a digital repository

Since the late 1980s, digital repositories have developed with the technological developments in computers and related digital technologies. Digital repositories take advantage of the possibilities offered by digital technologies to create archives in an online environment. However, functional distinctions remain.

Digital repositories were originally designed for publications, but become increasingly important for research data, software and other research outputs. Another feature is that they involve many partners: researchers, publishers, libraries, research infrastructures, etc., and consist of many building blocks: storage, network, computing, search engines and standards for metadata, security and legal conditions (ownership), operations and rules of participation (for providing content, for access and use). And there can be many options: repositories can be centralised, local, federated (connected) by scientific domain or region.

In setting up a repository one must decide on[46]:

- Purpose:
  - What: scholarly communication, learning materials and coursework, government publications;
  - Who is the audience: scientific community, economic sectors, society, central and local government;
- Scope: the context in which the repository is necessary:
  - Scientific domains;
  - Types of research output (data, publications, software, multimedia) within publications: theses, journal articles, preprints, reports, conference papers, book chapters;
  - Deposit types: formats that are supported (PDF/ODF, MS Office, video and audio formats);
  - Term of use: open, restricted, necessity for user to register or not, privacy policy;

45 It is possible for Timor-Leste to also consider a national museum, special archives on topics of national relevance, such as the independence movement. These options are not ruled out with the repository discussed and recommended for the INCT here.
46 Based on https://training.ni4os.eu/

- Software platform:
  - Typology: centralised; hybrid (centralised coordination and decentralised storage), decentralised;
  - Make or buy: standard tool or allow customisations, extensions and development of own tools;
  - Open source vs. commercial tool;
- Governance and resources:
  - Funding/financing, in-kind capacity;
  - Human capacity for technical support, training, outreach, etc.
  - IT infrastructure

In the following sections, we will take a closer look at the software platforms and provide examples that deal with the purpose and scope. With regard to governance and resources, we will first reduce the number of options.

5.1.2 Software platforms

5.1.2.1 Typology

The choice of a centralised – hybrid (central coordination and decentralised storage) – or a decentralised repository is to a large extent an organisational (and political) question.

- The simplest approach is to centralise both the coordination and content. Local users can log in at the central system and upload content.

- In the hybrid option, the coordination is still central, but the stored content is not. This requires adequate resources at each of the decentralised locations and requires strong coordination and monitoring on the use of appropriate (and agreed) standards. The advantage is that decentralised locations feel more responsibility and have the flexibility to add tools and services to their own (decentralised) system.

- A fully decentralised system requires adequate platforms that allow for easy and seamless aggregation of content (e.g. to provide a common catalogue). It requires agreement on such tools, and the standards that are being used for data exchange. This option may prevail when it is difficult to agree on a central, coordinating and supervising body (e.g. connecting national systems).

5.1.2.2 Make or buy?

Today there are many repository tools available, hence developing one's own system becomes less and less attractive as this requires a long development time, a large human capacity and a complex organisation of stakeholders, and the risk of not being connectable to other systems.

Within existing tools there can be options to do one's own additional development on top of the standard tool. This can be relevant when organisations want to connect the repository to other systems (financial database, projects database), but even for this there are (commercial) tools on the market, like Elsevier's Pure, which is a leading research information management system[47]. Sometimes (cf. Dataverse) the users' community can request additional tools or develop on their own and, when useful, the tool can be added to the main software.

5.1.2.3 Open source or commercial?

In public organisations there is a preference for open source. One important reason for this is to prevent 'lock-in' situations where the client becomes dependent on the supplier, e.g. when there is no possibility to export (and separate) content from the tool. Another reason could be high costs or annual subscription rates of commercial tools. An

47 https://www.elsevier.com/solutions/pure

advantage of commercial tools is that they are (mostly) turn-key or provide support, whereas open-source tools need extensive installation procedures that require considerable initial technical capacity and more IT resources and manpower for maintenance. However, even open-source tools (and their communities) help to properly install the software.

5.1.2.4 Overview of existing repositories

Repositories and open archives are continually being established. The OpenDOAR[48] (Directory of Open Access Repositories) website provides an overview of repositories and one can filter for required functionality, software type, content types and region. A search on national repositories for all content types reveals that many repositories are built using DSpace.

Other overviews can be found at:

- ROAR[49], which stands for Registry of Open Access Repositories. Selecting the software reveals that most repositories are set up in DSpace;
- ROARMAP[50], the Registry of Open Access Repository Mandates and Policies, which gives an overview of open access publishing policies;
- The European Open Science Cloud, EOSC[51], gives an overview of European tools and services, including catalogues of research data;
- Re3Data[52], the Registry of Research Data Repositories, which gives an overview of data repositories.

The following are popular platforms:

- The DSpace repository project at MIT[53], which contains all sorts of research outputs. It can be centralised, hybrid or decentralised. A description of the processing is in **Annex C**;
  Originally, it was set up as an institutional repository that captures, stores, indexes, preserves and redistributes the intellectual output of a university's research faculty in digital formats.
  DSpace uses open-source software and created a network of universities to work collaboratively – showing its capacity to function as a distributed system[54]. See the annex for a schematic overview of the processing of content.
- The University of California's system, which created the California Digital Library[55], a central facility for institutions. It uses Berkeley Electronic Press software licensed by the University of California.
- The Harvard Dataverse[56], an open source for designing data repositories.
- CERN's Invenio[57], a set of repository tools for data, publications and other research output. Its publication repository can assign DOIs as persistent identifiers.

48 OpenDOAR is the global Directory of Open Access Repositories: https://v2.sherpa.ac.uk/opendoar/
49 http://roar.eprints.org/
50 https://roarmap.eprints.org/
51 https://catalogue.eosc-portal.eu/
52 https://www.re3data.org/
53 http://dspace.org
54 https://duraspace.org/dspace/resources/technical-specifications/
55 http://www.bepress.com
56 https://dataverse.org/
57 https://inveniosoftware.org/

Invenio is a free software for running a digital library or document repository on the web and offers all aspects of digital library management, from document ingestion through classification, indexing and curation up to document dissemination.
Invenio was originally developed at CERN[58], managing over 1 million bibliographic records covering articles, books, journals, photos, videos and more. It is a free software, licensed under the terms of the GNU General Public Licence (GPL) and provided on an 'as is' basis, in the hope that it will be useful, but without any warranty. It is possible to get commercial support in case of interest. Invenio runs on Unix-like systems and requires a MySQL database server and Apache/Python web application server (both open source). The widely used Zenodo repository for data, publications and software is built using Invenio. Ethiopia's National Digital Repository, presented below, uses Invenio.

5.1.3 Existing National Digital Repositories and their functionalities

To support the decision process on the functionality of a National Digital Repository, we have described several repositories of scientific publications and research outputs in and across Southeast Asian countries, other Pacific countries, CPLP countries and others that may be considered suitable.

In the descriptions, the focus is on repositories that are routinely accessed by government institutions, higher education institutes and non-governmental organisations for uploading and downloading on a variety of devices. The descriptions aim to point at the functionality, scope (data, publications, other), organisation (central vs. distributed) and governance.

5.1.3.1 Norway

National setting: Norway has a relatively small population of 5.4 million. There are 10 public universities and several public and private colleges.

The Norwegian example goes beyond the regular purpose of providing a system for depositing and accessing research outputs. It also uses the repository for its science policy – to stimulate publishing in international journals and to keep track on productivity at university levels.

The Norwegian Government set up CRIStin, which stands for Current Research Information System in Norway. Researchers can register and profile publication data, projects, units and researcher profiles. It serves as the national research information system, it is owned by the Ministry of Education and Research and documents all scholarly publications by Norwegian researchers[59]. There is a strong incentive to deposit research output as part of the research budget is distributed based on CRIStin. Academic journals are assigned levels, which are used in science policy to encourage researchers to publish more in international journals.

The assignment of journal categories can be re-used in other national repositories, especially if governments want to promote publishing in specific (international) journals.

58 https://github.com/inveniosoftware/invenio/tree/v1.2.1
59 https://en.wikipedia.org/wiki/CRIStin

But to be effective there must be a tie-in with funding attached to the journal levels. This system is also being used in Denmark, Finland and South Africa.[60]

5.1.3.2 Iceland

Iceland is an island in the upper northwest of Europe and has only 366 000 citizens. It has 7 universities that together run 3 (centralised) repositories .

- Opin vísindi, built in DSpace, is for peer-reviewed articles published in open access and doctoral dissertations. Open access to research results is in accordance with Article 10 from the Act on public support for research / 2003 No 3[62] and is compliant with requirements from international and domestic research fund programmes.

- Skemman is the institutional repository for graduate and undergraduate theses.

- Hirsla[63] is designed as a place to store, index, preserve and redistribute in digital format the scholarly work of employees of the National University Hospital of Iceland.

The purpose of the open science repositories is to make the results of research conducted at Icelandic universities accessible to the public online, without hindrance or charge. Deposits to the repository are permanent and are intended to ensure future access to all published scientific material of the Icelandic research community. By collecting this material together in one repository makes access simple and easy for anyone who wishes to study the considerable scientific work conducted in Iceland.

5.1.3.3 Portugal

National setting: Portugal has a population of 10.3 million, and there are 13 public and 8 private universities, and numerous public and private polytechnic institutions. Like many European countries, there is a national network provider providing fast network connections and other IT-related services for research and education.

Portugal is an example of a decentralised approach that evolved to a hybrid system with central coordination, but decentralised responsibilities.

The University of Minho is one of the precursors in setting up (institutional) repositories. Their RepositoriUM stores, preserves, disseminates and provides access to the University of Minho's intellectual production in a digital format. In a first phase they had to configure the DSpace environment. Next, they began uploading doctoral and master theses and later on other publications. After extensive testing, the repository was made open for the public in 2003 with an initial 280 documents. Today the university collection hosts over 74 000 research outputs.

On a national level there is the RCAAP initiative[64] (Repositorio Cientifico de Acesso Aberto de Portugal). RCAAP is the aggregator (meta-repository) that gathers the description (metadata) of documents deposited in the various institutional repositories, data repositories and scientific journals in Portugal. The RCAAP portal does not save or archive any documents itself as this is done at the institutional repositories. There is also a connection to Brazilian scientific production (from the OASISbr project).

60 OECD Science, Technology and Industry Policy Paper No. 2020/89, https://doi.org/10.1787/20f80fa1-en
61 https://openaccess.is/repositories-in-iceland/
62 https://www.government.is/media/menntamalaraduneyti-media/media/law-and-regulations/Act-on-public-support-for-research-No.-3-2003.pdf
63 http://www.hirsla.lsh.is/lsh/
64 https://www.rcaap.pt/

Hence in Portugal there is a distributed structure of institutional repositories that are aggregated on a national level. It has the advantage of each university remaining responsible for the content (numbers and quality) of its institutional repository. It also allows some parties to be more active and add more services to their (institutional) repository than others. For Timor-Leste, the University of Minho's case is of interest as it was one of the first repositories in Portuguese and has good documentation about its design and implementation process.

5.1.3.4 Singapore

The National Research Foundation Singapore (NRF Singapore) requires all publications arising from its funded research to be made publicly available, no later than 12 months after the official date of publication. This so-called embargoed open access allows researchers to publish in any journal, including subscription journals, but the copyright holder (the author or the university) must ensure that they can submit the work to the repository.

The National University of Singapore Scholarbank[65] is an institutional repository for publications (including theses) and data. It has a pleasant user-interface with many filters (author, collections, department, issue date, subject, title, type), although 'subject' is not in a controlled vocabulary, which implies that 'Economic activity' and 'economic Activity' are two different topics. It also has 'recent submissions' and 'most viewed' and both stimulate researchers to deposit their material to be in these rankings.

The Nanyang Technical University has its own repository that reveals one of the drawbacks of decentralised repositories: it has a completely different user-interface and search & filter facility. Also, within this university, there is a separate repository for its National Institute of Education with another user-interface.

Institutional Knowledge at Singapore Management University (SMU) showcases the research and scholarly work of the SMU community. It also hosts the University Heritage Collection comprising oral history interviews and photographs, which could be a good example for multimedia data.

5.1.3.5 Indonesia

The Indonesian example is on data repositories – while most of the others are on publications. The reason for this was the poor quality of research data, the lack of overview and a need for re-using data (thus making it more efficient, cf. a recent study on life sciences data that revealed that providing an overview prevents duplication costs to a factor 60[66]).

In Indonesia, the National Scientific Repository (the Reporitori Ilmiah Nasional, or, RIN[67]) provides the means to share, preserve, cite, explore and analyse research data (PDDI-LIPI). The RIN uses Dataverse. The incentives for this national initiative were the scattered landscape of data repositories, and to verify scientific discoveries better and make it easier for other scientists to further contribute to the field. It currently contains over 4 000 data sets, which have been downloaded nearly 100 000 times.

This repository is dedicated to research data, which has the advantage of tailoring the services (uploading data, searching, accessing data) that are data-related. The disadvantage is that it is not integrated

65 https://scholarbank.nus.edu.sg/
66 https://www.embl.org/documents/wp-content/uploads/2021/10/EMBL-EBI-impact-report-summary-2021.pdf, p. 5.
67 https://theconversation.com/indonesias-first-scientific-data-bank-is-a-step-towards-strengthening-open-data-practices-126632; http://rin.lipi.go.id/

with other research outputs (publications, software and multimedia). The advantage of using Dataverse – besides being a standard and widely used tool for data repositories – is that it allows for other distributed Dataverses that can be easily combined into one (virtual) Dataverse. For example, the RIN consists of 502 separate Dataverses. However, a drawback can be that it is more difficult to control the quality of these 500+ separate Dataverses in a distributed setting.

5.1.3.6 Ethiopia

The scope of the Ethiopian example resembles the goals of the Timor-Leste Digital Repository: provide a large group of stakeholders' access to a national research output. It is a distributed system, which required additional investments in e-infrastructure in a national education and research (fibre) network, which can be costly and needs some time.

The National Academic Digital Repository of Ethiopia (NADRE[68]) intends to provide researchers, lecturers, students and stakeholders from outside academia access to all research works published by Ethiopian universities and research institutions.

The objectives of NADRE are:

- to increase the access of academics and citizens to research works published by Ethiopian researchers;
- to foster the dissemination of research outcomes and make them, as well as their authors, more visible inside and outside the country;
- to spread completed research across the country.

Currently, NADRE adopted Invenio and contains theses, dissertations, journal articles and conference proceedings from staff at Ethiopian universities. Each item will be tagged with digital object identifiers (DOIs).

It is a distributed system where each university has its own repository. This gives flexibility and puts responsibilities on depositing and the quality of the material with the universities. But it requires alignment on the use of standards (coordinated by the Education Science Center), and good and stable internet connections between the universities, for which Ethiopia has set up the Ethiopian Research and Education Network (EthERNet). It is possible for universities to host their repositories on a central server at EthERNet, but they themselves remain responsible for the curation of their own content. Its implementation included workshops to explain roles and responsibilities of the partners, a training plan, a website and a manual for the national repository.

This case shows that a distributed system can still have centralised storage; in other words, hardware facilities can be central, but content-related responsibilities are decentralised, making the universities responsible for their own content. It also gives an overview of support actions that need to be organised.

5.1.3.7 European Commission: Zenodo

Zenodo is an institutional service that evolved into a European service to host publications and data. It could serve as a checklist for functionality and is a good example of combining all types of research outputs.

Zenodo is hosted by CERN and has been built and developed by researchers, first in the EC-

68 https://nadre-repository.readthedocs.io/en/latest/introduction.html

funded OpenAIRE project and later extended by CERN for hosting data. Hence, Zenodo can deal with all kinds of research outputs (publications, data, software) and has extensions to assign a DOI for each object. It keeps track of the number of views and downloads, and citation information is also passed to DataCite and on to scholarly aggregators.

5.2 WHY A REPOSITORY FOR TIMOR-LESTE?

5.2.1 The benefits of a digital repository

Internationally, universities were among the earliest adopters of repositories and today, many other entities, such as governments, private corporations and not-for-profit organisations, also establish repositories to archive and preserve their institutional histories and administrative documents. Depending on the purpose, this material is publicly available or restricted due to sensitivity of the content or because of proprietary issues.

The Government of Timor-Leste, its universities and research institutions, and in collaboration with the economic sectors, can also use repositories in the same ways as universities and other countries do to document, store and access results from research, official documents, digitised historical artefacts, etc.

Timor-Leste has the potential to develop economic growth and reduce poverty. Important parameters are its human resource capacity, availability of natural resources and development in various economic sectors. However, this access to knowledge that is generated within the country and abroad is becoming more important.

A National Digital Repository can function literally as a gateway to the world, thanks to the omnipresence of the internet. In a digitised world, a repository can be used to promote and share the scientific and technological knowledge of Timor-Leste. It can stimulate its diffusion and practical application for the improvement of welfare in the country, in line with the National Strategic Development Plan (2011-2030) and the SDGs. The National Digital Repository can also be used to harvest relevant international information (scientific journals, teaching materials, studies, etc.). This information is mostly freely available, but given the relatively expensive international internet connections, key materials could be hosted in this repository as well. At this point it is important to note that due to open access initiatives, access to publications is increasingly freely available, but authors must pay article-processing charges (USD 500-10 000+) to publish. Despite the fact that many publishers have a waiver or discount policy for low to middle-income countries, it is recommended to have a budget for the article processing charges.

The recognition that knowledge capacities increase with use and access have led to the open access trends or even 'movement' (similarly supporting the trend to 'open archives' to enhance scholarly communication and dissemination) by removing barriers to access and increasing awareness. It should be noted that while an institutional repository

69 The government of Timor-Leste, at all levels, generates a significant body of information and knowledge. This is a critical part of the technological and economic infrastructure of the country, and it is essential this is widely available and in a useful and searchable database.

focuses on the intellectual output of a single laboratory, department, university or other entity, the goal of the INCT repository is national. With the development of the communications infrastructure and more powerful digital tools, it can enable the people of Timor-Leste to establish central facilities for storing, archiving, preserving and making scholarly and artistic materials available to all. Also, a national consortium can both reduce costs for its establishment and maintenance, and expand access to knowledge artefacts by digital means.

5.2.2 A repository is part of an ecosystem

As mentioned in the open science section in the chapter on STI, a repository is part of the (open) science system. For this, it must fit in a policy that opens the scientific processes: from collaboration with other stakeholders in setting the research agendas, to making science more transparent and changing the academic reward and recognition system, to changing the way scientists publish and share their findings, up to sharing scientific results (data and publications) beyond the own communities.

Hence, this new way of doing science is about greater efficiency and productivity, more transparency and a better response to interdisciplinary research needs. For universities and other stakeholders there needs to be a culture change[70]. As former European Commissioner Moedas formulated: "... new knowledge is created through global collaborations involving thousands of people from across the world and from all walks of life ..."[71]. No institution or country can afford to leave knowledge, data, reports and other results hidden on a laptop, without being shared. Sharing instead of owning is the new mantra.

5.3 DESIGNING A REPOSITORY

In **Section 5.1.1** we presented the main parameters for setting up a repository, namely:

- purpose,
- scope,
- software platform,
- governance and resources.

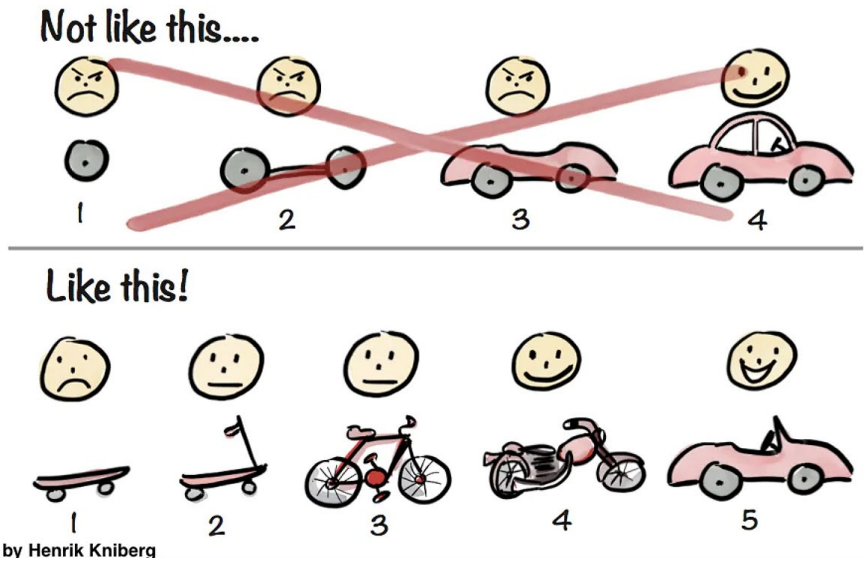
These items will be addressed in this section, but firstly, here is a quick analysis of the current situation: the need for developing an STI policy; the status of basic internet infrastructure and networks; the lack of adequate textbooks for education; the need for training and skills with respect to repositories; the move towards an approach to develop a minimum viable product (in this case a repository) in order to realise an operational system from which one can work on extensions and additional functionality.

5.3.1 Minimum viable repository

The principle of a minimum viable product (MVP) approach (**Figure 6**) is to start simple and get it working, then examine the directions it's going in to scale the size and scope. Instead of a long design period (top part of **Figure 6**), there is a quick design and realisation of some functionality, which lets users (and providers) get accustomed to the product and allows for quick, iterative improvements.

70 https://www.leru.org/files/LERU-AP24-Open-Science-full-paper.pdf
71 Moedas, C. (2015). Open Innovation, Open Science, Open to the World, Speech, 22 June 2015. http://europa.eu/rapid/pressrelease_SPEECH-15-5243_en.htm

Figure 6 **Minimum viable product approach**



Source: Author/Copyright holder: Henrik Kniberg. Copyright terms and licence: All rights reserved.[72]

5.3.2 Setting the parameters for a repository

Each (national) repository must decide on its parameters. Via interviews and co-creation workshops with stakeholders, a survey among the ministries and discussions with the INCT, a rapid prototype of a Timor-Leste National Digital Repository was co-designed and able to distinguish between the MVP and what can be developed later.

5.3.2.1 Purpose

The NDR must contain scholarly communication, learning materials and coursework, government publications and digital historical artefacts (from museums). It should also be able to collect international publications and data that are relevant for education and research.

The MVP approach starts with collecting national scholarly communication, but only universities and research institutions can upload content. In a later phase, learning material, government publications and historical artefacts can be added. In a third phase, international publications and data could be catalogued and harvested. For research software, there is a global repository, GitHub[73] that is a *de facto* standard.

However, a national discussion on which international publications should be available via the NDR could already begin. This is because of the open access developments that makes scholarly publications freely available. Instead of subscribing for access, the business models for journals move toward article processing charges (APCs) with the author(s)

72 Source: https://www.interaction-design.org/literature/article/minimum-viable-product-mvp-and-design-balancing-risk-to-gain-reward
73 https://github.com/

paying for the publication. These APCs vary but can become very costly. For publishers, the European Plan S[74] initiative requires that the journal must provide APC waivers for authors from low-income economies and discounts for authors from lower middle-income economies[75] (which includes Timor-Leste). It is important to organise access and APC agreements at national and international levels as university accreditation is an issue (libraries do not have licences to access journals). Waiver policies must be described clearly on the journal website/platform and statistics on waivers requested and granted must be provided. At the SHERPA[76] website, there are overviews on publishers' conditions for open access (Sherpa Romeo); funders' conditions for publishing open access (Sherpa Juliet); OpenDOAR on available repositories; and Sherpa Fact provides information whether journals meet funders' conditions.

From the start, the audience will consist of the scientific community, economic sectors, local and central government and society at large. It needs to be discussed as to whether users need to register or not – this will be addressed in later sections.

5.3.2.2 Scope

From the start, the NDR will cover all scientific domains.

The MVP approach starts with national scholarly publications: theses, journal articles, preprints, reports, conference papers and book chapters. Formats that are supported are PDF/ODF and MS Office.

Access will be open to all users, from Timor-Leste and abroad. A decision must be made as to whether users need to register. This will support the monitoring of use, but raises barriers to visit and use publications. A compromise would be to make searching and browsing freely available, but when downloading material, an email address is required. Note: registration might be required for accessing multimedia and research data. Special attention should be given to data protection.

In a next phase, multimedia will be added – this is because the ingest and metadata of these multimedia is different, the video and audio formats are different, and the storage capacity needs to increase significantly.

Research data will be covered in a later phase as this requires additional access control functionality. It might even imply a separate system that is dedicated to research data (cf. the Indonesia example). A trend on research data is to no longer download data but leave the data where they are and add computing and storage functionality.

5.3.2.3 IT platform

In the MVP approach, the NDR starts as a centralised facility: coordination is by the INCT and the content is stored centrally. Nevertheless, there can be advisory committees (on metadata, technology) that consist of stakeholders. Content from universities is uploaded to the central system. Central storage is preferred because of the reduction of network traffic (systems do not need to search and collect output from distributed systems), making it cost-efficient and better equipped to add new content providers (no need to install new hardware).

74 https://www.coalition-s.org/addendum-to-the-coalition-s-guidance-on-the-implementation-of-plan-s/principles-and-implementation/
75 https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups
76 http://www.sherpa.ac.uk

The NDR system can be open source, instead of commercial or being developed. This saves time, requires less technical expertise and is cheaper as open-source tools are freely available (only hardware and installation needs to be financed).

Software is a key element in the construction of an institutional repository. The Guide to Institutional Repository Software, published by the Open Access Society[77], is a valuable tool for selecting software appropriate to the needs and context of the institution and its repository.

Interoperability requires that repositories employ standards developed to handle issues associated with open access. These standards include the Open Archival Information System (OAIS) reference model[78], Open Archives Metadata Harvesting Protocol (OAI-PMH[79]), and the Metadata Encoding and Transmission Standard (METS[80]).

Other organisations involved in standards and repository design and operations include the Digital Library Federation[81], Coalition for Networked Information[82], OCLC[83], RLG[84], the electronic theses and dissertations program at Virginia Tech[85], and Creative Commons (CC)[86].

5.3.2.4 Governance & resources

As the NDR will be operated and coordinated centrally by the INCT, the funding will come from government (INCT) and other donors. Out-of-pocket expenses refer to the hardware, including its maintenance, and support for the installation of the software. For IT requirements, there need to be choices on system architecture, choice of standards, access capacity (number of users), with the possibility to scale and to bring down the initial costs; downtime indicators, etc. (see next section). In addition, there will be in-kind human capacity needed for technical support, training, outreach, etc.

The INCT will own the metadata (descriptions) – or at least these are freely available via Creative Commons (CC-BY). The content (publications) will be owned by the producer of the work. For new publications, an open access policy needs to be introduced. There are two possibilities for publicly financed research: the INCT will not be allowed to waive copyright (the university or government holds the copyright, like in the UK and USA); or, the second option is for publicly financed research outputs to be covered by a law similar to Germany and the Netherlands[87] that after a period of 3-6 months, the original producer is allowed to publish the work. This policy ensures that users of the NDR can safely re-use the material. For research data and multimedia, the ownership and copyright are more complicated and can be dealt with in a later phase.

Obligations with respect to descriptions (metadata) will be discussed in the section on 'standards'. It requires consultation with the stakeholders (in the MVP approach: universities and researchers) to decide on obligations to deposit a digital version of all research

77 https://www.budapestopenaccessinitiative.org/resources/guide-to-institutional-repository-software/
78 http://www.oais.info/
79 http://www.openarchives.org/OAI/openarchivesprotocol.html
80 http://www.loc.gov/standards/mets
81 http://www.dlf.org
82 http://www.cni.org
83 http://www.OCLC.org
84 http://www.rlg.org
85 http://scholar.lib.vt.edu/theses; http://www.thesis.org/standards/metadata/current.html
86 http://www.creativecommons.org
87 The German 'Urheberrecht' and in The Netherlands the Taverne law.

outputs (in the MVP approach: research publications), as is the case in Norway. Next to such an obligation, there must be sufficient support, like a helpdesk and a contact person (at the university libraries) for the researchers. Ideally, there is a positive incentive system for researchers, e.g. each publication in the NDR gets a DOI that increases its international visibility; universities get a bonus when their output is up to date; researchers get an award for the best Timor-Leste research paper and feedback on the number of its views and downloads.

The governance of the NDR can be described in a repository policy and must include:

- structure (information about the repository, its scope, owner, provider, platform, sharing, support, etc.);
- metadata policy for information describing items in the repository;
- data policy for full text and other full data items;
- content policy for document types and datasets;
- submission policy concerning depositors, quality and copyright;
- preservation policy concerning long-term retention, migration and withdrawal protocols.

5.4 BUILDING THE TIMOR-LESTE REPOSITORY

5.4.1 Introduction

These options for designing a National Digital Repository were used as input for a virtual workshop with the INCT, the national team and stakeholders in February 2022. Other starting points were that Timor-Leste currently does not have a repository (no legacy issues), and that the INCT wants to create the repository and has the legal regulation for its establishment.

5.4.2 Purpose

The purposes for a National Digital Repository are:

- to hold archives of all digital research outputs, materials for (higher) education, digital historical artefacts and official government publications from Timor-Leste;
- to hold catalogues and provide access to relevant international digital research outputs;
- for information to be easier to access for all citizens of Timor-Leste and beyond.

5.4.3 Scope

- The digital repository can contain textbooks, articles, videos, audio books, lectures, simulations, fiction and all other kinds of learning media related to scientific material.
- The national repository should also collect information from international digital libraries, as well as other relevant sources.
- The ability to assign/address ownership (including copyright, CC-BY licenses) – this goes for the content as well as the description/metadata.

88 See https://v2.sherpa.ac.uk/opendoar/policytool/ for further explanation of the separate policies.

5.4.4 IT platform

5.4.4.1 Technical infrastructure

The preconditions for an IT platform are:

- internet capacity for international connectivity:
  - an option would be to set up a NREN for Timor-Leste via the GÉANT organisation;
- setting up national internet capacity;
- setting up an intranet (limited number of access points) with the universities and research institutes.

And for the NDR are:

- software, for running the repository:
  - a centralised repository, but with the ability to include or connect with other (decentralised) repositories;
- OAI-PMH[89], which enables other archives to access the NDR database;
- hardware to host the database and NDR software;
- a network capacity to facilitate access to users.

5.4.4.2 Implementing standards

- Metadata standards for publications and data to set up metadata profiles that connect to other global standards:
  - schema.org connects to Google;
  - Dublin Core for publications;
  - OpenAIRE connects to OpenAIRE Europe and Zenodo;
  - various domain-specific metadata standards, like the Data Documentation Initiative for Social Science and Humanities (see the Research Data Alliance Metadata Directory[90] for an overview);
- Persistent identifiers:
  - DOI or Handle for publications and data;
  - ORCID identification[91] for individual researchers;
- Controlled vocabularies and ontologies, multilingual thesauri:
  - to be able to filter searches using closed categories, and to ensure that content providers use the same categories in their metadata;
  - thesauri can be used to provide a multilingual search within the NDR.

5.4.5 Governance & resources

5.4.5.1 INCT as the owner of the National Digital Repository

The INCT is a regulatory body for all scientific investigations, and the continuous promotion of scientific and technological innovation issues (see previous chapters).

- Legal issues:
  - Legal framework for the National Digital Repository is in place;
  - The legal deposit will belong to the INCT;
  - All publications will have to go through the INCT to get the ISBNs/ISSNs. In addition to ISSNs, this could/should also apply for DOIs/Handle (persistent identifiers for journal articles and other

89 https://www.openarchives.org/pmh/
90 https://rd-alliance.github.io/metadata-directory/about/
91 Freely available via https://orcid.org/register but to ensure completeness there should be a university / NDR policy that researchers must have an ORCID number.

non-book publications and data) – the INCT will be the contracting party.
- Information about procedures for management of copyrights and intellectual property rights, and with regard to transnational usage of digital repository resources, other legal issues.

- Funding:
  - Arrange a budget for the starting and implementation phase (2023/2024);
  - Organise the human resources to set up and run the infrastructure (in-kind capacity);
  - Adapt functionality to budget and human resource capacity (start with the MVP approach);
  - Secure long-term budget for the growth phase (2025-2027) and consolidation phase (2028-2030).

- Housing:
  - Location for the IT-equipment; IT support staff could work from distance;
  - Backup facility at least 30 km from the server facilities.

5.4.5.2 Other key stakeholders

It is important to provide clarity on the roles.

- Government, especially the MESCC and other ministries:
  - Budget;
  - Ministries as content providers, and as users of the NDR.

- Service providers:
  - Telecommunication Information Communication (TIC), to provide support on the technical part plus maintenance of the system, and to ensure that the NDR's architecture is scalable;
  - Telecom and IT companies, internet providers.

A lot of server capacity will be required for data server hosting, especially in the growth phase.

Software developers are needed to implement the NDR, and connect the universities to log in on the NDR.

All operators should have a direct connection to the server based in Timor-Leste. They must look for local traffic.

- Content providers:
  - Universities,
  - National Library,
  - Museum of National Resistance,
  - Ministries,
  - Economic sectors (companies).

- Users:
  - Researchers,
  - Students,
  - Ministries,
  - Citizens,
  - Companies.

5.4.6 Processes

There follows a brief description of the processes that are present when running a digital repository.

- Preconditions:
  - Internet capacity (international and national);
  - Server and Central Processor Unit capacity to run the NDR;
  - Required expertise; the specific expertise required for the set-up of the repository.

- Setting up the NDR:
  - Information about procedures for accessing and downloading materials, for example, what kinds of search protocols could be used;
  - Information about procedures for uploading/contributing to/storing information, including quality control;
  - Information about procedures for the management of copyrights and IPR, and in regard to transnational usage of digital repository resources;
  - Information about models for the efficient and cost-effective translation, versioning, adaptation of materials from one language to another; etc.

- Deposit:
  - All academic publications should be submitted to the INCT;
  - Organise the deposit process together with the universities and research institutes;
  - Rules of depositing;
  - Provide information on the obligatory and desired information (metadata);
  - Determine via policy as to whether depositing digital research output (initially publications) should be made obligatory. Note: distinguish between backup/archiving working material and output that is to be published;
  - Organise support and a helpdesk – preferably at each university (via its library).

- Ingest & harvest:
  - Legal deposit: establish the copyright;
  - Quality assurance (plagiarism, for instance; digital research output that goes into the system data should be verified (viruses);
  - Organise security issues on the server: data protection and good governance.

- Curate & enrich:
  - Interoperability through Application Programming Interface (APIs) to ensure a safe and reliable system;
  - Option to add additional metadata or connect outputs (e.g. publication and research data);
  - Check on the presence of persistent identifiers (ORCID for authors; ISBNs/DOIs for publications and data; connect research data with publications using Scholix[92], and eventually a research grant number by using CrossRef[93]);
  - Information about models for the efficient and cost-effective translation/versioning/adaptation of materials from one language to another; etc.

- Publish:
  - The digital research output and its description (metadata) are made available in the NDR.

- Dissemination & outreach:
  - Training is needed for producers and other providers of materials; clarify the role of librarians (training, helpdesk, outreach, etc.);
  - Promote the use of the NDR to (new) users.

5.4.7 Mitigation of risks

It is relatively easy to set up a system. The challenges are to keep the system up and running, to keep it safe from cyberattacks and other abuse, to encourage content providers/authors to submit material and to ensure the quality of the content. In order to mitigate

92 http://www.scholix.org/
93 https://www.crossref.org/

the risks from the start, it is good to set up a monitoring system for the following:

- Costs:
  - The internet is very expensive. Set up one good international connection and bring the relevant international information into the NDR so that national users don't need an international connection;
  - Hardware – use international benchmarks;
  - Staff – use international benchmarks on the number of staff required;

- Number of providers and number of deposits; trends are more important than absolute numbers;

- Number of users:
  - By stakeholder group, including international; trends are more important than absolute numbers;

- Quality NDR platform:
  - International benchmarks – see the next subsection.

5.4.7.1 Criteria for repositories

These criteria are based on Plan S[94], which was developed at the European Commission and is supported by many national research funders, universities and publishers. Plan S has the following checklist for repositories:

1. The repository must be registered in the Directory of Open Access Repositories (OpenDOAR) or be in the process of being registered.
2. Persistent identifiers (PIDs) must be used for the deposited versions of the publications (with versioning, for example in case of revisions), such as DOI (preferable), URN, or Handle.
3. High-quality article-level metadata must be in a standard interoperable non-proprietary format, under a CC0 public domain dedication. This must include information on the DOI (or other PID), both for the original publication and the deposited version, and on the open access status and the licence of the deposited version. Metadata must include complete and reliable information on funding (including as a minimum the name of the funder and the grant number/identifier).
4. Machine-readable information on the open access status and the licence embedded in the article, in standard non-proprietary format.
5. Continuous availability (uptime at least 99.7 %, not taking into account scheduled downtime for maintenance or upgrades).
6. Helpdesk: as a minimum an email address (functional mailbox) must be provided; a response time of no more than one business day must be ensured.

Strongly recommended additional criteria for repositories:

7. A manuscript submission system that supports both individual author uploads and bulk uploads of manuscripts (accepted author manuscript (AAM) or version of record (VoR)) by publishers or universities.

94 https://www.coalition-s.org/addendum-to-the-coalition-s-guidance-on-the-implementation-of-plan-s/principles-and-implementation/

8. Full text stored in a machine-readable community standard format such as JATS XML.

9. Support for PIDs for authors (e.g. ORCID), funders, funding programmes and grants, institutions and other relevant entities.

10. Openly accessible data on citations according to the standards by the Initiative for Open Citations (I4OC).

11. Open API to allow others (including machines) to access the content. A compliant API must be free to access without any barrier. A light authentication mechanism such as a token for 'power users' – e.g. high-traffic collaborators – is acceptable as long as there is also a totally open/anonymous route.

12. Compliance of the metadata to regional and global standards.

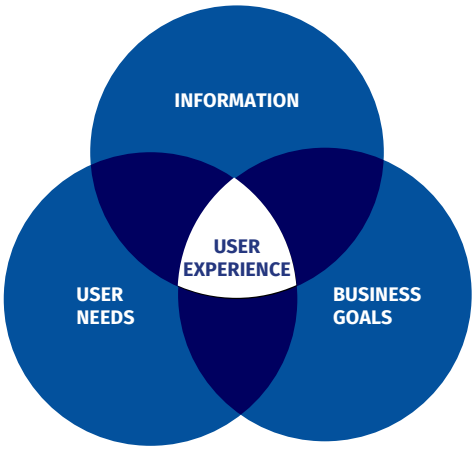
13. Quality assurance processes to link full-text deposits with authoritative bibliographic metadata from third party systems, e.g. PubMed, Crossref, or SCOPUS where feasible.

5.4.8 Rapid prototyping

The design will consider the user experience (**Figure 7**), based on the user's needs, the identified pain points, and the (business) goals and information available and harvested. This is an iterative process, which means that foreseen functionality may change throughout the process.

The co-creation workshop on the NDR enabled the definition of its functionality, purpose and goals, and with this input and additional ideas of existing repositories there was a second co-creation session that focused on rapid prototyping: what are the essential parts of the NDR and what would these look like?

Figure 7 **User experience process**

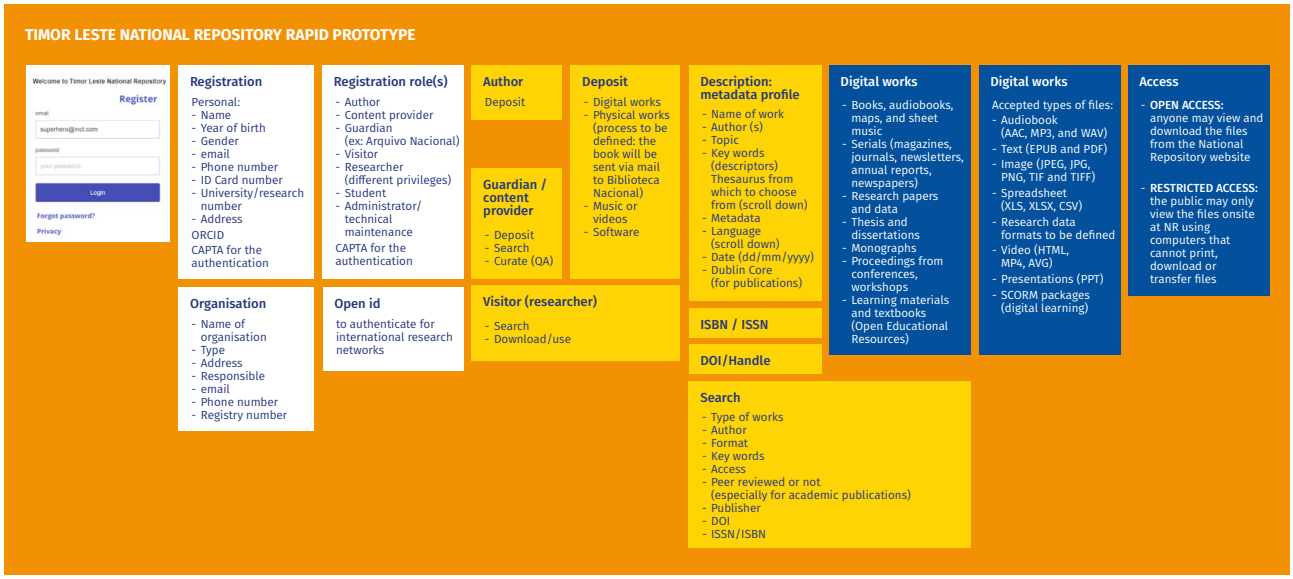


Source: Kozielski, Borys; UX diagram, under CC licence.[95]

95 https://commons.wikimedia.org/wiki/File:User-experience-diagram.png

The result is in **Figure 8** below.

Figure 8 **Rapid prototyping on repository functionality**



Source: Authors' own elaboration.

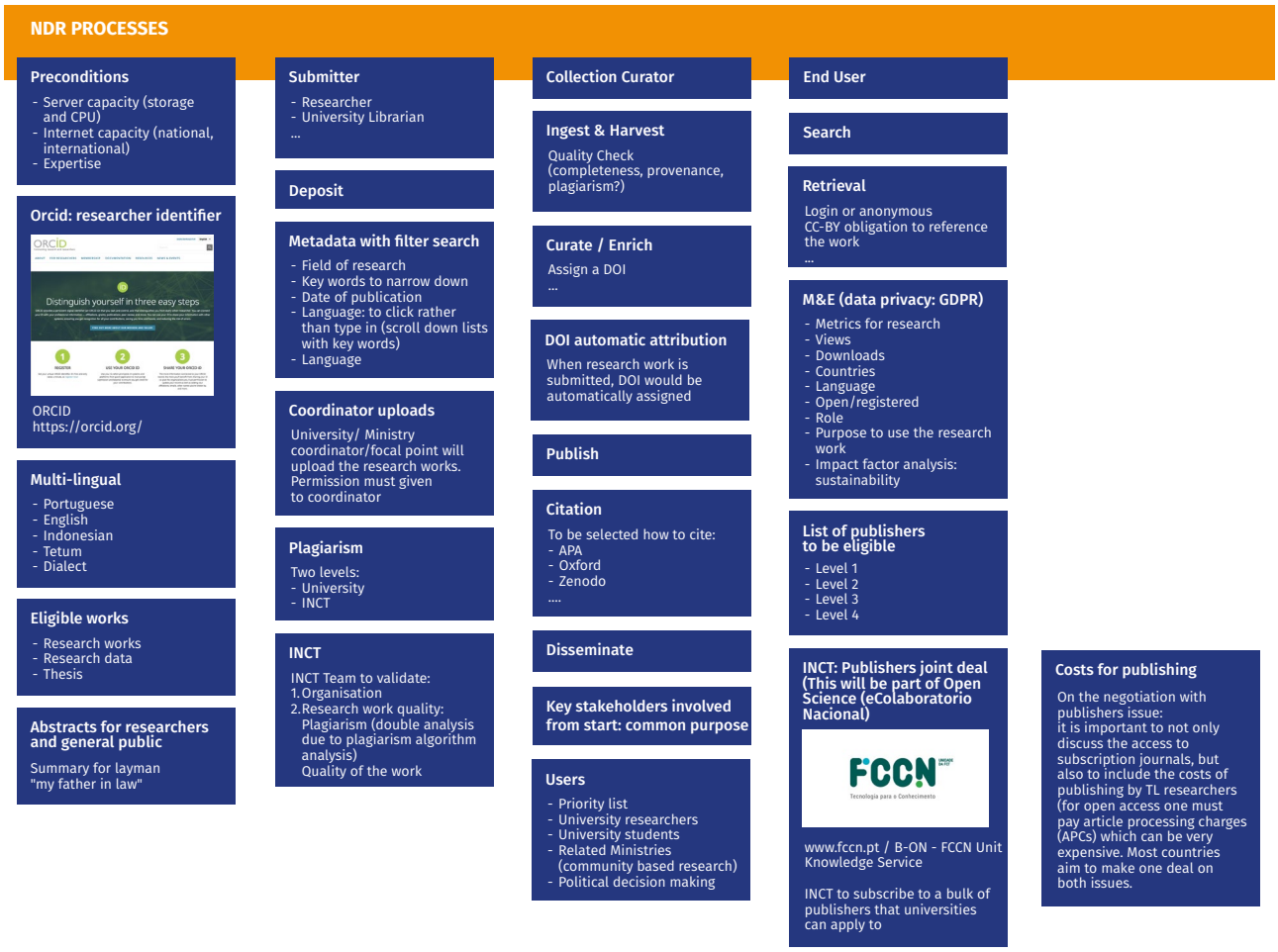
On the left (in white) there is a login (by researchers as content providers) and the information that is collected for both the individual researcher and the organisation. The 'Registration role' describes possible roles up to the option to ask visitors to register as well. 'Open id' is used to connect with other (international) networks.

Next (in yellow), roles are defined: 'Author', 'Guardian' and 'Visitor'. For the 'Author' the NDR needs information on the type of 'Deposit' (same for 'Guardian'), and for 'Visitor' the functionality must be defined – especially if the NDR requires registration when downloading information. The 'Description' gives information on the type of metadata that must be added to the deposit. The information on persistent identifiers (ISBN/ISSN for books; DOI/Handle for scholarly articles) is part of the description and needs to come with the deposit. Under 'Search', the filters that can be used to limit the number of records are defined – this will also depend on the type of repository that is chosen.

The parts in blue describe characteristics of 'Digital works' like Type and Format; and it distinguishes between open and restricted access, which also needs to be one of the 'Deposit' characteristics.

A third session, during a second co-creation workshop with national stakeholders, elaborated on the NDR processes. It describes how the different users deal with uploading, curating and using a scientific document (see **Figure 9**).

Figure 9 **Rapid prototyping on repository processes**



It is worth noting that this rapid prototype enabled the achievement of NDR technology readiness level[96] (TRL) 2, with the basic principles observed and defined (TRL 1), and the technology concept and processes discussed (TL2).

5.4.9 Next steps and timeline

5.4.9.1 Governance

The INCT, following its mandate, will manage the National Digital Repository in the long term with regard to the allocation of budgets and preparing human resources for the establishment and maintenance of the National Digital Repository.

5.4.9.2 Management and staff to be allocated

There will be a National Director of the Digital Repository who will be assisted by at least 2 technical experts who are qualified for operating the NDR. There will be 2 researchers and some assistants to serve the users and content providers of the NDR.

96 Horizon 2020 – Work Programme 2014-2015, Technology Readiness Levels, 2014; https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf

There will be at least 1 researcher from each main science domain (social sciences and humanities; life sciences; environment sciences; exact sciences and technology) to manage the standards.

There needs to be at least 1 member of the library staff at each university research institute and government body to support the uploading of content locally.

5.4.9.3 Training (experts)

The training of experts should aim to create a common understanding of what is open access and open science in Timor-Leste. These experts need to attend the following:

- Participate in international conference or events about open access and open science;
- Depending on the technical solution selected, attend technical events and webinars related to the NDR's installation and deployment;
- Co-creation sessions to design the NDR's different functionalities, testing the prototype and MVP approach, along with defining the processes with the different key stakeholders are highly advised.
- After the definition of the processes, specific further training sessions will be required to align the institution's staff, namely librarians and knowledge gatekeepers, on how to use the NDR in its different functionalities. Short workshops and webinars (which can be recorded and kept as OER training material) can be launched to further deploy the NDR.
- Some of the possible topics to be covered:
  - Open access,
  - Open data and FAIR principles,
  - Open software and hardware,
  - Publications and pre-prints,
  - Finding and accessing open access,
  - Finding and accessing open data,
  - Copyright and flexible licences such as CC,
  - Successfully build open-source software and hardware,
  - Citizen science.

5.4.9.4 Outreach & promotion of use

The outreach and promotion of use is a critical activity to reach scalability and sustainability. It is therefore highly recommended to start basic training and webinars around open access and open science, even before the NDR is in place, to create an appetite and start engaging the key stakeholders upstream. These outreach activities can assume very diverse forms, from face-to-face to hybrid events or fully online, such as webinars. These events should be engaging with experiential, inquiring, problem or project-based learning approaches to drive use and application in real life contexts, and supported on open science and citizen science principles.

- Co-creation sessions to design the NDR's different functionalities, testing the prototype and MVP approach, along with defining the processes with the different key stakeholders are highly advised.
- Webinars.
- Hackathons.
- Design dashes to wicked problems, such as agriculture or environment.

The topics would be defined based on the works available in the NDR and the target groups, thus creating a unique training and applicable training experience addressing the target groups' needs:

- Open science and citizen science;
- Finding and accessing open access applied to a specific area of the target groups' needs;
- Finding and accessing open data applied to a specific area of the target groups' needs;
- Developing open-source software;
- Coding for STEM.

5.4.9.5 Timeline

Below, in **Table 8**, is presented a timeline for the NDR technical implementation, aligned with the funding strategy recommended above, consisting of the preparation, creation, growth and consolidation phases until 2030. A more detailed planning is in **Annex B**.

Table 8 - Aggregated planning for the National Digital Repository

	Phase	Prepa-ration	Creation		Growth		Consolidation	
Action	Activity	2022	2023	2024	2025	2026	2027	2028+
1	**TECHNICAL IMPLEMENTATION**	√	√					
2	**CONTENT**		√	√				
2a	National publications		√	√				
2b	International publications			√	√			
2c	Research data			√	√	√		
2d	Government publications				√	√	√	
2e	Digital historical artefacts (museums)					√	√	√
3	**OUTREACH**		√	√	√	√	√	√
3a	Researchers and students as immediate users		√	√	√	√	√	√
3b	Extend users to ministries, companies and society			√	√	√	√	√

5.4.10 Budget

Setting up a National Digital Repository requires initial investments in hardware, software (including installation), annual maintenance and updates, and staff at both the centre (core/hub) and the universities (spokes).

Following the minimum viable approach, the NDR starts with publications from Timor-Leste researchers and relevant international publications. For this the storage capacity can remain limited, but when data and multimedia are added, the capacity for storage and network (download) capacity will increase significantly. The software is open source, but will require service providers that support the installation (including background software such as standard query language databases) and setting the parameters of the NDR tool. The Timor-Leste NDR may require investments in a national network between it and the universities (cf. the Ethiopia case). A first estimate is that an investment of EUR 300 000 would be required for the hardware, the installation and maintenance in the first 2 years, and the national network between NDR and universities.

In the first phase, there would be a need for the following staff:

a. Core staff: 1 national director; 2 technical staff (including technical coordination, maintenance and updates); 2 research experts (including connecting with users – via university contact points) and 3 research assistants; 1 communication officer; 1 office manager (see Section 5.4.9).

b. Identifiers (ISBN, DOI): 1-2 ISBN and DOI experts – with support/helpdesk contracts and subscriptions with ISBN and DOI service providers.

c. Training & support: 2 training experts (including community building); 1 contact point per university/institute.

The need for experts will grow when multi-media and research data will be included; and when international contacts grow additional outreach staff might be required.

6 Conclusions and recommendations

The work done and reported in this document aims to support Timor-Leste on its road to building and using STI policies and infrastructure for contributing to its development goals. The report has been arrived at in close cooperation with the INCT and national stakeholders, to harness the potential of STI policy, coherent with the 2022 HENP, and to enhance national human resource capacity in a systematic way.

The INCT is to develop a gateway to international knowledge and facilitate and stimulate the absorption of (inter)national knowledge within Timor-Leste. The report highlights the importance of this step to develop a national STI system.

6.1 CONCLUSIONS

The new HENP calls for an inclusive, open and sustainable STI strategy and framework, especially focused on the linkages between higher education and science, and links them to longer-term, sustainable government policies and cooperation with the productive needs in the country.

The urgent need for the setting up of a STI programme and a NDR was emphasised throughout the implementation of this PSF service by all national stakeholders, who all stressed that we live in an era of digital technology where knowledge creation and distribution is occurring at an increasingly rapid pace. If Timor-Leste wants to catch up, it must go digital as well.

A future STI policy should be embedded in open science, and based on the quadruple helix, which is to be inclusive by allowing for the participation of all relevant social actors. The INCT has the role to articulate further, and develop and consolidate a national system of science and technology, research, development and innovation in the strategic areas for the country.

This report elaborates on a National Digital Repository. Its main functionalities are described, along with the different options. It has achieved technology readiness level[97] (TRL) 2, with the basic principles of the rapid prototype created being observed and defined (TRL 1) and the technology concept being discussed (TRL2). The report advises on the next steps with respect to governance, management and organisation. This report also provides a first estimate of the required budget and staff.

97 Horizon 2020 – Work Programme 2014-2015, Technology Readiness Levels, 2014.

6.2 RECOMMENDATIONS

6.2.1 STI policy

The Timor-Leste Government should allocate funding and manpower to the INCT to set up and sustain a long-term STI policy, starting with the concrete STI policy actions envisaged. It is recommended to set a goal of 0.25 % of GDP being allocated for research, to be increased to 1 % after 5 years. In addition, there could be a target for a percentage on R&I investments by the private sector.

This budget dedicated to STI activities must include a budget for open access publications and subscriptions to academic journals. In open access publishing, authors must pay article-processing charges (APCs) to publish and as long as there are still subscription journals, it may still be needed to pay for these journal subscriptions as well. A budget needs to be defined at state level and negotiations need to occur to form a national deal on both APCs and subscriptions, making use of experiences from other countries, in order to bring down the costs.

Activities and (public) investments must be checked that they meet the RRI principles and climate-neutral criteria.

Develop and deploy an open science policy that makes data FAIR (by design), makes publications and other research outputs freely available to society at large, and encourages the development and availability of open educational resources.

We advise to base the STI policy actions on the four pillars provided, following a holistic approach. In this approach, it is important to start establishing international partnerships to support their design and uptake in Timor-Leste. The legal framework is recommended to be further extended following the areas already identified in the HENP and in this report.

This report includes a feasibility study for the National Digital Repository (Pillar 2), but it is recommended to set up feasibility studies for the federated Open Science Cloud (e-Colaboratorio; Pillar 3) and for physical infrastructures (Pillar 4).

Investing in national coalitions to join forces and increase efficiency is also one of the key recommendations of this report. One of the options here is to establish a campus where science and industry meet. Another option might be to set up a national data infrastructure coalition with major data service provides (INCT, research institutes, National Statistics Office, TIC and others).

Collaboration with national stakeholders is also a key element. It is important for the INCT to connect with MESCC and other ministries, industry, the telecom sector and other stakeholders at national and regional levels. This includes setting up communication channels and the development of courses, setting up webinars, etc. For this, best practices from other countries could serve as a starting point.

To reach scalability and sustainability of the STI policy, it is highly recommended to start basic training using webinars around open science, even before the NDR is in place, to create an appetite and start engaging the key stakeholders upstream.

It is also critical to monitor and analyse progress, e.g. by acquiring evidence on the implementation of the STI policy, to understand and demonstrate to all stakeholders what is working well, and what changes are needed to work from an evidence-based policy to continually develop and improve practices.

6.2.2 National Digital Repository

In order not to lose momentum it is highly recommended to create the NDR as a MVP that starts with the most valuable requirements, based on the rapid prototype developed during the co-creation workshops. The NDR also starts as a centralised system, coordinated and hosted by the INCT.

As a next step, the parameters for setting up a NDR must be set. For this we advise that an exploitation plan is worked out, describing details and choices made in a coherent and consistent way. For example, the NDR software should be selected after the NDR strategy and vision are defined, along with the functionalities. The open source-selected software should support them and not dictate what they should look like. A template for the selection of the NDR software tool is also provided in **Annex D**.

An initial budget of EUR 300 000 for investment in the hardware, the installation process and the software installed is highly recommended. In addition, Timor-Leste should allocate human resources (technical experts and researchers) to develop, maintain and expand the NDR.

A key feature of a National Digital Repository is its sustainability. Content providers, developers and users need a long-term (at least 10 years) perspective, otherwise they will not engage, nor provide content and start using the NDR. A sustainable NDR will also encourage international partners to engage and connect with Timor-Leste and so launch the e-Colaboratorio Nacional.

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ANNEXES

A. INTERVIEW SCRIPT AND QUESTIONNAIRES FOR MESCC AND OTHER MINISTRIES

The script was used as a starting point for the various interviews. Depending on the topic, the focus of the interview could shift and ad hoc questions could be added.

Governance

- What strategies or plans exist or were drafted, besides the current feasibility study being drafted and the United Nations Technology Bank, to provide an overarching strategic direction to national STI policy and a repository?
- What arrangements are planned or are already in place to support cross-government coordination in STI policy and national repository creation? Who is responsible for this? How is the coordination taking place or how is it foreseen?
- Are there any arrangements or governance structures existing to initiate, perform or encourage the use of STI evaluation and impact assessment? How is the repository going to be used to support this?
- Are there any arrangements or policy initiatives to strengthen the evidence base for STI policymaking and governance (besides evaluation and impact assessment)? If not, are they already being planned? Who is planning them? Who is involved in the process? How is the repository going to be used to support this evidence-based STI policy and other policies, for instance with open data and fostering open science?
- What arrangements are planned or exist to support the international governance of STI policy (e.g. joint strategies and agreements, horizontal coordination or regulatory oversight bodies, besides the PSF)? With whom? And what is covered? Why are they considered strategic for Timor-Leste's STI? Are there any international arrangements in place or being envisaged for the repository?
- What STI policy debates are being held in Timor-Leste? How? And by whom? And how frequently? Are these debates also tackling the repository? If so, what aspects are covered?
- What are the emerging STI trends envisaged in Timor-Leste? And national repository trends?

Public/private research system

- What is the current research system in place? Universities, research institutes, other institutions (public and private, if applicable)? Are they using repositories? At national and international level?
- What are the main ongoing policy debates around government support for Timor-Leste's public research system? And how does it connect to the national repository?
- What strategies, roadmaps or plans exist, if any, to provide strategic direction to national research policy? And repository(ies) to support it?

- What are the main competitive schemes and programmes for funding research in universities and public research institutes? Private universities and research institutes? Is there an open science policy included in the conditions for funding research (e.g. data management plan). Is there a copyright policy? (And who holds the copyright? The institution or the researcher?) And responsible research and innovation? Open access policies?
- What are the main non-competitive schemes and programmes for funding research in universities and public research institutes? And in private?
- What policy initiatives exist, if any, to promote third-party funding of public research? And private?
- Is the oil Fund part of these schemes? How do you envisage its use in this realm?
- What policy initiatives exist, if any, to support or lead structural changes in the public research system? For instance, implementation of open science?
- How do you envisage the use of the oil Fund in this context?
- What policy initiatives exist to support open science and enhanced access to publications and research data, if any?
- What are the main policy initiatives for funding new and existing research infrastructures and large equipment in Timor-Leste? How would you envisage this possibility? Provide an overview of the existing and future infrastructures and who the key stakeholders are.
- What are the main policy initiatives for promoting internationalisation in public research? With which type of institutions, sectors/thematic areas (transdisciplinary, interdisciplinary)? Geographies? Countries?
- What are the main policy initiatives for promoting interdisciplinary research (integrating disciplines, e.g. psycho-economics; geo-economics)? And transdisciplinary (for economic and social impact, SDGs)?
- What policy initiatives exist, if any, offering dedicated support to high-risk research? And what can be considered high-risk research in Timor-Leste?
- What are the main policy initiatives for promoting research integrity and reproducibility?
- What are the main policy initiatives for promoting open research and open science?
- What policy initiatives exist to incorporate sex and gender specificities in research content (e.g. questioning gender assumptions in research methods)?
- What policy initiatives exist to incorporate indigenous specificities in research content (e.g. questioning indigenous assumptions in research methods)?

Capabilities for STI

- What are the main ongoing policy debates around government support for the development of capabilities for research and innovation?

- What national strategies or plans exist, if any, to foster capabilities for research and innovation in Timor-Leste? Has the INCT been engaged in this role already?
- What are the main policy initiatives for nurturing general STEM skills? Are they being considered with gender and indigenous-based approaches?
- What policy initiatives exist to specifically support doctoral and postdoctoral research and education in Timor-Leste and abroad?
- What policy initiatives exist to encourage international mobility of the highly skilled? What are the main drivers to prevent brain drain? How are those who stay abroad being engaged to further foster Timor-Leste development?
- What is the research career mobility policy, if any, for researchers?
- What policy initiatives exist to make research careers more attractive? And in the STEM sector?
- What policy initiatives exist, if any, to help ensure researchers will have the necessary skills to drive and reap the benefits of the digitalisation of science, at this stage? And in the future?
- What policy initiatives exist to promote the participation of women and other under-represented groups (indigenous population) in research and innovation activities?

Repositories

- What is the goal of the repository?
- What must be available from the start; what can be developed in a next version?
- What must be covered?
  - external scientific publications (peer-reviewed articles, books)
  - internal scientific publications (research memoranda, grey literature)
  - societal publications (social media, newspaper articles)
  - presentations (PowerPoints)
  - datasets
  - software
- It is a requirement that any output will get a persistent identifier (PID) – e.g. DOI or Handle.
- Scope: all universities and research institutes, or other scope?

B. DETAILED NDR PLANNING

In addition to the planning in **Chapter 5** for the NDR, this table gives a more detailed overview, especially on the steps that are needed.

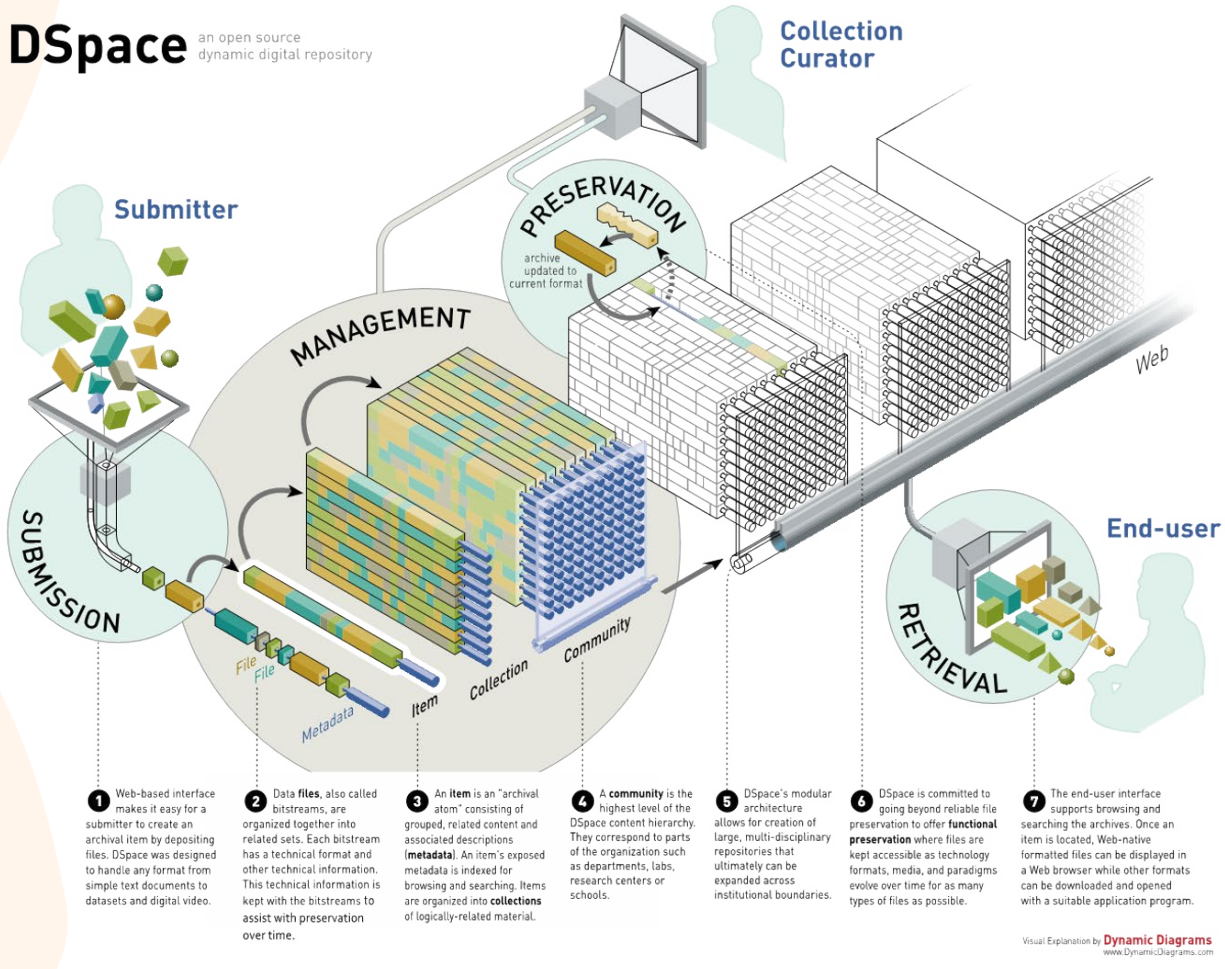
Table 9 - Aggregated planning for the National Digital Repository								
		Phase	Prepa-ration	Creation		Growth			Consolidation
Action	Step	Activity	2022	2023	2024	2025	2026	2027	2028+
1		**TECHNICAL IMPLEMENTATION**	√	√					
1	1	Arrange governance, incl. advisory committees on IT, NDR, standards	√						
1	2	Appoint core NDR staff: Director, Technical Staff, Helpdesk	√						
1	3	Selection process for the NDR software	√						
1	4	Determine IT hardware requirements and acquire IT	√						
1	5	Implementation of the NDR software		√					
1	6	Set standards – technical and metadata		√					
1	7	Test run of the NDR		√					
2		**CONTENT**		√	√				
2	**a**	**National publications**		√	√				
2	1	Appoint contact points at university libraries		√	√				
2	2	Training of contact points		√					
2	3	Pilot: add 10 publications per university		√					
2	4	Evaluation on processes (deposit; ingest; curate; publish)		√					
2	5	Evaluation on content quality; completeness of metadata		√					
2	6	Open the NDR for content providers – publications		√					
2	**b**	**International publications**			√	√			
2	7	Working group – science, education – to do selection			√				
2	8	Checking on copyright and ownership issues			√				
2	9	Adding international publications to the NDR			√	√			

Table 9 - Aggregated planning for the National Digital Repository								
		Phase	Prepa-ration	Creation		Growth			Consolidation
Action	Step	Activity	2022	2023	2024	2025	2026	2027	2028+
2	**c**	**Research data**			√	√	√		
2		steps 2a 1-6			√	√	√		
2	**d**	**Government publications**				√	√	√	
2		steps 2a 1-6				√	√	√	
2	**e**	**Digital historical artefacts (museums)**					√	√	√
2		steps 2a 1-6					√	√	√
3		**OUTREACH**		√	√	√	√	√	√
3	a	Researchers and students as immediate users		√	√	√	√	√	√
3	1	Information and training on how to use NDR		√					
3	2	Set up a user group for feedback		√	√				
3	3	Evaluation on content and functionality (user-interface)			√	√	√	√	√
3	**b**	**Extend users to ministries, companies and society**			√	√	√	√	√

C. DSPACE PROCESSING CONTENT

This figure describes the process of content (publications, data) through the DSPACE system.

Figure 10 **Processing content in DSpace**



D. NDR SCORING AND SELECTION FORM

This table can be used for the selection of the NDR Software Tool (SWT). It starts with defining knockout criteria (in red), and deciding on the categories – here are software specifications, metadata standards, PIDs, controlled vocabularies, other, and then the items with these categories.

Next the reference or maximum score has to be determined, and then a committee or group of independent reviewers can do the scoring. If there is a group, then the results can be used to check for lack of clarity (e.g. when the scores are very different).

As the SWT is open source, there is no fee. If there would be costs of installation (e.g. by a service organisation), then a price can be incorporated. A weighted scoring method is used for this:

*Lowest total proposed cost/Proposer's total proposed cost * Available price points = Price score.*

For example, if the installation costs for SWT1 are USD 60 000 and the lowest cost score by SWT3 is USD 40 000, and the available price points are 50, then the score for SWT1 is 40/60*50 = 33.3 (out of 50). The score for SWT3 is 40/40*50 = 50. Note that the setting of the amount of available price points is very important and needs to be determined beforehand.

Table 10 - Template for NDR software tool selection						
	Reference score	SWT1	SWT2	SWT3	SWT4	SWT5
NDR software specifications	**45**	**0**	**0**		**0**	**0**
Open source (fundamental prerequisite)		Yes	Yes	Yes	Yes	No
OAI-PMH enables other archives to access NDR		Yes	Yes	Yes	No	
Centralised repository, but ability to include or connect with other (decentralised) repositories	25					
APIs available	10					
Can hande multiple languages (at least 3, preferable 5)	10					
Metadata standards for publications and data	**30**	**0**	**0**		**0**	**0**
Set up metadata profiles that connect to other global standards	15					
Schema.org connects to Google	2					
Dublin Core for publications	5					
OpenAIRE connects to OpenAIRE Europe and Zenodo [and/or similar for Asian-Pacific region)	5					
Various domain-specific metadata standards, like DDI for Social Sciences & Humanities	3					
Persistent Identifiers	**10**	**0**	**0**		**0**	**0**
DOI or Handle for publications and data	5					
ORCID identification	5					
Controlled Vocabularies and Ontologies, multilingual Thesauri	**10**	**0**	**0**		**0**	**0**
To be able to filter search using closed categories – and to ensure that content providers use the same categories in their metadata.	5					
Thesauri can be used to provide multilingual search within the NDR.	5					
Other	**5**	**0**	**0**		**0**	**0**
Availability of regional support team (both installation and support during operations)	2					
	1					
	2					
Total score	**100**	**0**	**0**		**0**	**0**

E. TIMORESE INSTITUTIONS CONSULTED

Institutions
Agência Nacional para a Avaliação e Acreditação Académica
Assosiasaun Peskizador Timor-Anan (Timorese Research Association)
Dili Institute of Technology
Instituto de Ciências Religiosas
Instituto Nacional de Ciência e Tecnologia
Instituto Nacional de Saúde
Institute of Business
Instituto Politécnico de Betano
Instituto Professional de Canossa
Instituto de Petróleo e Geologia
Instituto Superior de Cristal
John Snow Incorporation
Ministério do Ensino Superior, Ciência e Cultura
Ministério Do Turismo, Comércio E Indústria
National Authorising Office
National Language Institute – Universidade National De Timor Lorosa'e
Universidade Oriental De Timor Lorosa'e
Universidade da Paz
Universidade Nacional de Timor Lorosa'e

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