Sustainable Local Socio-Economic Development Through Astronomy

I. Introduction

Astronomy is generally seen as a "luxury" science that only first world countries can afford. It is often believed that it is a science that requires expensive infrastructures, and is of no use for economically disadvantaged countries, especially the many African countries that face socio-economic challenges. For this reason, astronomy very often appears as a low-priority science. However, the unique ability of astronomy to stimulate curiosity in the minds of young children and adults alike, as well as imagining possibilities, gives it a special place among the efforts to address development challenges.

In the hope of changing the current perspective and using astronomy as a tool to contribute to socioeconomic development in the world and particularly in underdeveloped countries, the International Astronomical Union's Office of Astronomy for Development (IAU-OAD) has funded several projects that aim at addressing some of the development challenges.

In this document we provide a synthesis of some projects that aimed at using an astronomical facility as a hub within a small town or village to stimulate various associated socio-economic benefits for the local community, and provide a few guidelines for future such projects on how to optimise their outputs. We particularly focus on the specific case of "astrotourism" and the promotion of STEM education through astronomy, two types of projects that directly impact some of the United Nations Sustainable Development Goals (UN SDG).

II. Lessons from past projects

II.1. Examples of results

The past projects funded by, or conducted in collaboration with the OAD have generally shown to improve the socioeconomic development status of the targeted populations. In this section we summarise a few examples of local socio-economic impacts of community projects conducted either by organisations in partnership with the OAD, or observatories around the world.

- With the construction of the large SALT telescope[1] in Sutherland, a development-driven benefits programme named SCBP (SALT Collateral Benefits Programme) was established to make the local communities profit from the presence of the telescope. The programme focuses on education in science, technology, engineering and mathematics (STEM), science communication and awareness, socio-economic

[1] The Southern African Large Telescope is funded by a consortium of international partners from South Africa, the United States, Germany, Poland, India, the United Kingdom and New Zealand.

development, and public engagement. The needs assessments of the programme have been conducted through consultations with the communities, stakeholders, municipalities, etc., and emphasis was put in addressing the many challenges affecting the local communities such as unemployment, alcoholism, drug abuse and teenage pregnancy. The efforts to promote education in STEM and socio-economic development are translated by projects such as the creation in Sutherland of a Community Development Centre (CDC) and the enhancement of a visitor centre to improve tourism in the region. The CDC was established to serve as a rallying point of development in the community of Sutherland and to facilitate the improvement of the socio-economic well-being of the town of Sutherland. For example, over the past 4 years (2015 to 2018), the observatory has been able to attract a total of more than 50,300 visitors to Sutherland, as a result of the various activities and astronomical events it organised. This makes SALT one of the greatest attractions for people to visit the Northern Cape province, and the observatory actively participates to the socio-economic development of the local village and surrounding areas by creating jobs for the youth in the local communities. A 2019 study[2] found that, as at 2017, about 6% of the Sutherland population were directly employed by the observatory while a combined 20% indicated that they had derived some benefits from SALT and alluded that the observatory had provided employment for a member of their family. This clearly shows the positive contribution that the observatory has on the economy of the town. Regarding the promotion of STEM-related fields, the improvement of education in STEM is achieved through various activities including teacher trainings, school visits and learner workshops and job shadowing programmes. In this framework, the SALT annual report states that over 46,000 school learners were reached in 2016 through workshops and school visits, and over 1800 teachers were trained in the form of 2-7 day long teacher training workshops.

- Partly funded by the IAU-OAD, the Community Development Around Timor Observatory project has partnered with the Indonesian Institute for Energy Economics (IIEE) to develop a symbiosis between a prospective astronomical observatory in Timor, Indonesia, and its surrounding community. As of 2016, the project had managed, through a thorough survey, to successfully identify the needs of the local populations of the villages around the site of the observatory. The project team has repetitively engaged with the local populations, and has led meaningful dialogue with the local authorities to ensure a participative synergy between the observatory and the locals. This is important mainly because it represents one of the safest means to obtain quality inputs about the aspirations and fears of the populations, therefore allowing to adjust the objectives of the community development project. Although the project is not fully completed yet, it has already implemented a human capacity building programme

[2] Vorster J. and Eigelaar-Meets I. 2019, Sutherland: Socio-economic characteristics, Cosmopolitan Karoo Research Report

by empowering human resources through an office financial management training of public officers, and through a training programme of school teachers in STEMs. The team conducting the project has noted that, in order for the project to fit in smoothly with the local communities, there is a need to reconsider subtle issues such as political and cultural issues in the villages around the observatory. Engaging with the public has been identified as an important aspect of the project in order to build trust and familiarise with the different parties, and various activities such as public talks and participations to local festivities have been proposed.

- Among the several efforts made by the ALMA observatory to contribute to the development of the host country Chile, we note the creation of jobs for the local communities (80% of the ALMA staff are locally hired) and the implementation of a program to improve the education in science and English in a local public school. To help start and facilitate the implementation of the program, the observatory has provided training, selected and financed the hiring of teachers and built needed infrastructures. It has also provided hands-on material and periodic feedback on program implementation through education specialists and as an outcome, the program has helped to improve the students' results in national standardized tests[3] and has been acclaimed by the local authorities. Besides investing in education and various infrastructures, the observatory has committed to building a visitors' centre in the local community. This will allow to promote its outreach initiatives, contribute to the development of scientific knowledge of visitors, and help position the area as one of the main tourist attractions in Chile. Finally, the observatory has partnered with a local museum and local stakeholders to promote the preservation of the local cultural heritage and its vision of the cosmos through an ethno-astronomy project designed both in Spanish (Chilean official language) and English.
- Focusing on promoting astro-tourism in southwest Asia, the OAD-funded *"Development of Astro-Tourism in South West Asia"* project has gathered several organisations such as the IAU's South West and Central Asian (SWCA) regional OAD, the Byurakan Astrophysical Observatory (BAO), Armenian Astronomical Society (ArAS), the Armenian Academy of Sciences (NASRA) and the Armenian Institute of Tourism (AIT) through numerous activities conducted in 2016. The highlights of these activities are a series of visits of astronomical sites to promote them and the organisation of conferences and science camps. These astronomical sites include ancient and modern observatories, space and astronomy-related museums, planetariums and astronomical visitors centres. An important outcome of the project is the creation of materials to promote astro-tourism in the southwestern asian region. These are mainly *(i)* the publication of a booklet about the BAO in order to make the astronomical sites widely known to the public and help attract visitors and *(ii)* the

[3] According to the ALMA website

creation of dedicated websites[4,5] to serve as working environments between travel agencies and astronomical sites for development by providing useful information on tour packages and organizing tours. The project is still continuing its activities with support from IAU100, and a dedicated website is expected to be up soon.

- In their effort to improve the quality of life in remote areas across India, the Global Himalayan Expedition (GHE) partnered with the IAU-OAD to implement an astrotourism programme in unelectrified villages located in the higher reaches (above 3500m) of the Himalayas. Due to lack of access to energy and development opportunities in these villages, the local communities mostly live below the poverty line, with agriculture and animal husbandry being their main activities. As a result, many locals tend to migrate towards cities and less remote areas, where opportunities are more accessible. By providing clean energy access to many of these remote communities through solar micro-grids, the GHE has been able to create development opportunities. To further develop the economy of the region, the GHE initiated an OAD-funded "Astronomy for Himalayan Livelihood Creation" project that promotes astrotourism in these rural Himalayan areas. The project team trained women in the communities both on tourism and hospitality, then selected families capable of hosting tourists in the electrified villages. These homestays are advantageous for both tourists and locals, as they allow an intercultural exchange and a bond between both parties. Tourists are furthermore offered the opportunity to take advantage of the high altitude and dry climate of the Ladakh region to enjoy star-gazing with provided sophisticated telescopes. The astronomy flavour constitutes an additional source of attraction for tourists, by providing unique offbeat experiences to the intrepid travelers. On the other hand, these astro-homestays create a source of meaningful livelihood for the communities who, in the process, develop their knowledge of celestial bodies and increase their appetite for science. The astro-homestays are promoted through an online platform, where potential tourists can book a homestay from about 30 USD. To date, 55 homestays have been set up and are currently hosting tourists, generating a total income of 135,000 USD (GHE website). In addition to this, the figures from just one village where the astrotourism programme is up and running show that the astrotourism experiences have generated an impressive revenue of around 1000 USD in just two months. Because the project focused on empowering the local communities, especially women, a total of 140 jobs have been created, the communities comprise 45 women entrepreneurs and 10 trained solar engineers, supporting sustainable development in the villages.

II.2. Lessons

[4] http://iau-swa-road.aras.am/eng/AstroTourism/
[5] http://www.aras.am/SciTourism/eng/index.php

II.2.1. Community needs assessment and community engagement

The team of the project focused on community development around the Timor observatory carried a thorough community needs analysis by emphasising on community engagement, allowing them to identify the challenges faced by the local communities and their expectations from the observatory. The needs analysis was performed thanks to an extensive study, during which data were collected through a survey. The experience with the project showed that one of the best practices for carrying the needs analysis involves conducting interviews with the targeted communities, and querying demographics data from local or regional authorities. This is because a complete survey of the local populations can sometimes be quite challenging as it requires time (up to a few months depending on the size of the communities) and human resource. The engagement with the local populations remains an important aspect in carrying a community development, as this not only allows to build trust between the project team and the communities, but also allows to efficiently identify the needs.

II.2.2. Astrotourism

The various projects discussed above demonstrate that astrotourism, a form of tourism that involves historical and modern astronomical sites and facilities, may significantly contribute to tourism — hence socioeconomic development — given the growing interest towards science, and in particular towards astronomy. For example, the number of “bed and breakfast” accommodations for tourists in the town of Sutherland has grown from two in 1998 to about 60 nowadays, including 18 guest farms. This increase, which is largely due to the implementation of the observatory and the SCBP, generates revenue and boosts the socioeconomic development of the town. Furthermore, this facilitates the creation of jobs in the communities, combating the rate of unemployment which has been identified as an origin of alcoholism and drug use among youths in these communities. If well implemented, an astrotourism programme can be a powerful tool to boost the socioeconomic development of a rural area. However, a study recently conducted in the town of Sutherland by an OAD team revealed that there can be a challenge in evenly distributing the benefits of astrotourism in communities. In fact, nearly all the existing businesses (guesthouses, guest farms, etc.) which benefit from the growing astrotourism programme are owned by the wealthy (mostly caucasians) minorities and non-locals who have the financial means of starting a business. Although efforts were made to initiate an entrepreneurship programme intended for the disadvantaged communities, the programme failed to be sustainable due to the absence of resident professionals in the town.

Moreover, it was noted that there is little to no interaction between locals and the tourists who visit the observatory, mainly because guesthouses are either out of town, or located in areas where most locals cannot afford to live. This lack of interaction creates a barrier between locals and tourists, leading to a disinterest of the populations for the

programme. One way to address this is to initiate a homestay programme similar to that of the astro-homestays of the Astronomy for Himalayan Livelihood Creation discussed in section II.1. This way, one ensures a cultural exchange between locals and tourists, and a better involvement of the communities in the project. Also, this is one of the best ways of directly generating revenues to the communities who have limited financial means of starting a formal business.

II.2.3. Education

Most of the education-centered projects target schools in the communities around the relevant astronomical facility, which must be the prime focus of the said projects. The activities must be centred on outreach programmes in schools, preferably in the communities targeted by the development project related to the astronomical facility. This involves organising activities aimed at both the school learners and the teachers; the latter which must receive a certain level of training in astronomy and astronomy-related fields to spark and maintain the interest of learners in STEMs.

III. Guidelines for future projects

III.1. Site selection

The selection of the site to host the astronomical facility should be made carefully. Several aspects such as cultural, political and environmental aspects should be looked at. It is important that the construction of the facility does not degrade the ecosystem, and does not interfere with the cultural activities of the locals. The local authorities must always be consulted when a potential candidate site has been identified, and the project team should ensure that they obtain (written or verbal) consent of the relevant authorities before the site can be chosen. It is also necessary to ensure that safety is guaranteed, and the designated zone is not target to conflicts. If a political stability does not exist in the region, the facility will not be able to be fully operated. A case example of this is in Burkina Faso where a site designated to host an observatory had to be relocated because terror attacks had targeted the region hosting the site.

Once the political, cultural and environmental questions have been addressed, the project team must ensure that existing technological facilities will not constitute an obstacle to the use of the facility. For example, if the said facility is an optical telescope, then one must ensure that light pollution will not be an issue. There exist several resources online[6] which a map of light pollution can be obtained from. It is the responsibility of the project team to provide a clear light pollution map of the area, that includes legends, labels and scales. For radio telescopes, any radio interference such as cellular phone signals must be prohibited within a certain perimeter, so such facility is not advised near a town or village. The team must also make sure that access to the site is

[6] e.g., https://www.lightpollutionmap.info, https://darksitefinder.com/map/

not a major issue, i.e, it is preferable if there exist roads linking the site to the surrounding towns or villages.

III.2. Community analysis

The objective of community needs analysis is to identify the resources and tools that will benefit the populations living in the targeted communities. This is an essential step in any development-related project, and should form the basis of the discussion in deciding about the nature and size of the astronomical facilities to build or install. Furthermore, because the project is aimed at contributing to local development, it is imperative that the local communities are associated with the process. It may be useful to investigate how the construction and operation of the astronomical facility can benefit from the facilities already available on and around the site, but also how the communities can benefit from the astronomical facility. If the implementation of the facility does not provide development infrastructures (such as running water, electricity, education tools or programs, tourism, etc.) to the communities, then the selected site may not be suited for the project. For example, here are some of the questions that one needs to address to assess the impact of the implementation of an astronomical facility:

- What are the existing facilities in the targeted region and how can they benefit the facility?
- Are there accessible schools in the targeted area? What are the literacy rates of the targeted communities?
- What is the average age of the population in the area? Are they mostly young or old?
- Will the implementation of the astronomical facility be able to attract visitors in the area?
- Will the astronomical facility be able to create jobs for the local populations in the long term?

Below we provide a few guidelines in conducting a needs assessment.

a) The PESTLE analysis

A needs analysis may be carried out within the framework of a PESTLE (Political, Economic, Sociological, Technological, Legal and Environmental factors) analysis. Flagship project proposers are encouraged to briefly conduct an environmental scan analysis using the PESTLE framework i.e:

Political factors – things to consider may be whether or not there is political will and support for the project not only at the national, but also at local level. Obtaining the support of local councillors, mayors and traditional leaders will be crucial. If there is political instability in the area it may affect the success of the project; otherwise the project may then be more suited for the Flagship 2 theme.

Economic factors – Here, demographic data is useful in giving a full picture of the socio-economic conditions in the area. Things to consider would be the level of development (as also proxied by Night Lights for example). The collection of demographic data can be

achieved in several ways, from researching public records data to observation, surveys, questionnaires and personal observation. Where the project proposers have no access to data, they can enquire with the OAD as it may be able to have better access to economic data. It will also be interesting to obtain a profile of the current baseline population and projections of how that population is likely to change over time. If the project seeks to create jobs for the local communities, then this study is important to assess its impact on the economy of the region over time. It will also serve as a baseline to evaluate, in the future, if the implementation of the facility has impacted the demographic data of the region.

Sociological factors – Here there may be need to consider cultural aspects of the local area, perceptions towards science and women participation, levels of education, etc. It is important to ensure that the project is well understood by the local communities, and avoid any risk of clash with the cultural beliefs. A series of meetings, e.g. in the form of public talks and debates, will be necessary to engage with the communities. It will also serve as a way to gauge their aspirations and get to establish a trust between the different parties involved in the project.

Technological factors – This analysis is useful because it reveals the current state of technological adoption in the area. Questions to ask would be whether we have electricity, internet, etc. Mobile phone penetration rates will also determine whether to promote awareness on the project via phone, internet or word of mouth for example.

Legal factors – The team needs to consider the astronomical facility with respect to the legal environment. For example, we may not want to displace a community in the name of building a facility, or occupy a piece of land that has been classified by the authorities.

Environmental factors – This is about how the astronomical facility will impact the natural environment**.** It is important to ensure that the implementation of the facility does not degrade the ecosystem in any way.

b) The SWOT Analysis

The Strengths, Weaknesses, Opportunities and Threats should not be a separate analysis. Instead, it should be carried out in conjunction with the PESTLE analysis, i.e., identifying the SWOT elements in each of the PESTLE sub-components. The Flagship project should capitalise on the Strengths and Opportunities, and suggest ways that it will counter the Weaknesses and Threats. Figure 1 below is important in carrying out a SWOT analysis.

Figure 1: SWOT Analysis

Strengths and Weaknesses	**Opportunities and Threats**
These are internal factors, for example internal to the project team or local areas. Strengths could be the qualifications of the	These are from the external environment e.g., threat of a natural disaster occurring

project team, while weaknesses could be limited funding.	in the area, while an opportunity might be a supportive political environment

c) Small survey (formal or informal)

The project proposers need to have a near accurate view of the needs in the area. But before a survey is carried out, a series of information campaigns (through e.g., public talks and meetings with the communities) must be organised to sensitise about the goals of the projects. While we can infer from available census and survey macro and micro-data, additional information from locals will be key in ensuring that our targeting of the projects is efficient. The project proposers do not necessarily need to implement a formal survey, but they can informally obtain information amongst their circles (extended family, neighbours and friends). It is important to ensure a diversity in the sample of interviewees, including people of different genders, age and ethnic groups. Example of informal interview/talk text is shown in Box 1 below:

Box 1: Informal Talk in Restaurant or community club

Member of Project Team: "Friend, you know I am involved in astronomy. Tell me, if a mini-observatory was to be built in our area, how many times do you think you would visit it?"
Friend Response: "Perhaps twice every month"
Member of Project Team: "Say payments were required to visit the facility, how much would you be willing to pay per visit?"
Friend Response: "I would pay 1 dollar per visit"

The project team just needs to record these conversations and repeat them with a couple of responses (the more people the better). While these interview samples would not necessarily be representative at the population level, it is a rich wealth of information that we can use to predict the success of the project. Information on prices and quantities will allow to estimate some kind of demand function and ensure that we dedicate resources/funding efficiently.

d) Willingness to pay (WTP)

Data from formal/informal interviews such as in Box 1 can allow both the project team and the OAD to estimate a demand function and have an idea of WTP projections that will be useful in ascertaining the feasibility of the project(s).

III.3. Community engagements

For the project to succeed, it is imperative that the targeted communities are involved in the process. The project team must ensure that they engage with the communities, e.g.

by including locals in the team and by regularly holding meetings in the town/village to discuss relevant issues. This could be done through forums in which the different communities are represented. The community engagement is particularly important, and should be done at every major step of the project: during the design, implementation and monitoring of the project.

III.4. Feasibility Analysis

Once the needs have been identified, it is important to conduct a feasibility analysis. This serves to assess the practicality of the proposed project, and evaluate the expected project return given the investment.

a) Project returns (return on capital employed)

The OAD is not a profit seeking enterprise. However, projects that will manage to obtain some financial (or other beneficial) returns will have more sustainability and have a better chance of continue running than those that will perpetually require external funding. Some price (WTP) and quantity data from the local area (through formal/informal surveys) will allow the OAD support office to compute some rates of return which can perhaps be used to rank and prioritise projects. These rates of return projections can then be compared with actual performance post implementation and the amount of learning that will result on the part of the OAD is tremendous. It is worth noting that benefits can also be non-financial, e.g., reduced drug abuse by youths. But these benefits can also be translated into financial gains by looking at how much a local clinic/hospital may save per youth saved from drug abuse and future drug-related illness.

b) Demand analysis

Using information from the informal/formal surveys together with other available indicators (Human development index, levels of education, income levels, etc. in the area), the OAD can assist the project team by computing some correlation and regressions using all these information in order to better the decision making process.

III.5. Partnership

Besides the OAD, the project team must seek to establish partnerships with other related organisations at regional, national or international levels. The goal of this is to enable collaborations with other organisations specialised e.g. in the field of astronomy, tourism, community engagement or evaluation, and learn from their experiences. It also is important to partner with government or private agencies that can assist the project in providing commodities such as access to electricity and water. Examples of organisations could be other astronomical facilities (such as observatories), research facilities, tourism and travel agencies, etc. Furthermore, if the project comprises an education component, a partnership with local schools or higher education institutes is strongly encouraged.

III.6. Project monitoring & evaluation

In order to ensure the sustainability of the project, monitoring and evaluations need to be constantly done. For this, a steering committee can be put in place to oversee the project activities and manage the general course of the operations. This is important because it gauges the impact of the project mainly on the targeted local communities. More information on this step can be found at this OAD webpage.

III.7. Possible objectives of community projects

There are several ways to design projects to benefit the communities. For example, these can be focused on promoting education and/or astrotourism. Below we provide a few additional, more technical guidelines specific to some of these focuses.

III.7.1. Education

The first step in designing a development programme to promote STEM education using an astronomical facility is deciding whether the programme will primarily target public outreach for the public and school learners, or it will rather focus on higher education through the development of an astronomy curriculum and research projects.

a) Public outreach

If the focus of the project is to promote STEM-related fields through public outreach activities, then the site designated to host the astronomical facility must be accessible to the general public. The facility must serve as a rallying point of STEM fields in the targeted community. Also, a particular interest must be given to young girls and underrepresented minorities in STEM fields.

b) Tertiary education projects

The first action to take in this category is clearly lay out the science and the type of projects that will be conducted with the telescope. For this, a partnership or collaboration with a (preferably local) university or tertiary education institute is compulsory, since such projects will be intended for university students. Also, this category of programme requires a careful selection of site, especially regarding the quality of the sky, as a good quality science can not be conducted if light pollution remains a problem to deal with. The activities to be developed in this category must be centred around student training through research projects, and the experience with the Tony Fairall teaching telescope at the University of Cape Town has shown that a telescope diameter of 10-14 inch equipped with a CCD camera can be used.

III.7.2. Astrotourism

A simple google search with “astrotourism” as keyword returns about 49,000 results, with several articles and websites promoting tourist destinations. There even exist a few

websites (e.g, astrotourism.com, chile.travel, andalucia.org) dedicated to proposing to the general public, information about astronomical facilities and stargazing sites, just like hotel booking websites do. The sector has gained a growing popularity worldwide over the last few years, and as such, draws the attention of more and more tourists around the world. For example, a New York Times article published last September and entitled *"Your Next Trip? It's Written in the Stars"* explores the growing popularity of the field across the world, particularly across the United States, Canada, Mexico. The article acknowledges the efforts of organisations such as the International Dark-Sky Association (IDA) and the Royal Astronomical Society of Canada (RASC) to preserve the sky from light pollution by designating several dark sky parks and reserves across the american and european continents. It also highlights several astrotourism sites across the Americas such as parks and resorts, and activities like festivals organised for the public. These give a glimpse of how popular the astrotourism business has become, and how it will shape the future of tourism.

Astrotourism is in fact defined as a form of tourism that uses the unpolluted night skies, and appropriate scientific knowledge for astronomical, cultural or environmental activities (Fayos-Sola & Marin 2009). What makes astrotourism suited for community development is that, unlike several other forms of tourism, it emphasises on the conservation of natural resources and as such, is suited for sustainable development.

For an astrotourism programme to thrive, there is need of a solid professional approach to both the destination site and the product management (Fayos-Solà et al. 2014). If this is the main theme of the astronomical facility, efforts must be put to ensure its sustainability. Like any tourism destination, a 3-step analysis and policy process is necessary for a successful astrotourism programme (UNWTO, 2010; Fayos-Solà & Alvarez 2014). These consist of:

– A *green paper* of the site presenting a detailed inventory of the resources available. This phase, which is needed to study the feasibility of the programme, identifies the existing products and support services that will benefit the programme. Of course the main resource is the astronomical facility, but the project team needs to inventory all other resources that may be useful in ensuring the sustainability of the programme. For example, one needs to ensure that the quality of the night skies from the observatory is appreciable, and that there is enough scientific knowledge or human resources to conduct the project. Also, if there exist other tourism products and facilities around the site, it may be necessary to make use of them. The project team must also make an effort to contact local authorities, community leaders and potential stakeholders during this phase to examine possibilities, and associate them to the project.

– The second step of the process consists of establishing a *white paper* of strategic decision-making, where the necessary resources, support services and tourism products are selected. At this stage, a complete analysis of the sustainability and robustness of the astrotourism programme must be performed. This is the stage where the PESTLE and

SWOT analyses described above must be carried out to assess the area, both internally and externally, for astrotourism activity. A clear and concise report on the resources available and proposals about their use must be obtained at the end of this phase. An emphasis shall be put on the socioeconomic benefits for the local communities, with respect to the needs assessments established earlier.

– In the last phase, a tourism policy plan must be developed to ensure the success and sustainability of the project. As described in Fayos-Solà et al. (2014), this plan is basically a structured set of sub-programmes to analyse market conditions, attract visitors, and satisfy the needs of both the local communities and visitors. The sub-programmes that must be designed are:

- *Activities*: the aim of this sub-programme is to design activities and workshops that will attract visitors and maintain the life to the astronomical facility.
- *Data*: this sub-programme aims to continuously mine data and provide information regarding all the components of the astrotourism operations. A steering and/or advisory committee will then analyse these data and suggest the way forward to ensure the sustainability of the programme.
- *Sustainability*: the main resources of the programme are the astronomical facility and the clear night sky; this sub-programme will ensure not only the conservation of these resources, but also the availability and preservation of the natural and cultural resources in and around the site. The sub-program must also identify potential threats to the well-functioning of the astrotourism programme, and establish norms and guidelines to prevent and/or curb them.
- *Innovation*: closely related to sustainability, the innovation sub-programme serves to support the astrotourism programme by not only bringing innovating over existing astrotourism programmes, but also recurrently bringing changes to the astrotourism site, products and activities to keep the programme up to date.
- *Cooperation*: it is important for the well-being and survival of the programme to collaborate with other local and foreign institutions. These institutions, besides the IAU-OAD, include governmental institutions, tourism and astronomical facilities, etc. It is particularly important to establish a solid collaboration (e.g., through an MoA) with astronomical research facilities across the world with a long experience in research and development.
- *Fundraising*: the availability of funds is essential to the operation of the astronomical facility. This sub-programme investigates ways of collecting funds to maintain the facility in the long term, from private and public partners/sponsors to the revenue generated from the astrotourism activity.
- *Knowledge and human capital*: this sub-programme particularly focuses on creating and enhancing human capital. It ensures the availability and quality training of tour guides and providers, and also guarantees the creation of scientific content and interpretation of astrotourism resources and products.

- *Products and promotion*: the astronomical facility and its related astrotourism activities must be advertised and promoted to the public to attract visitors, and all the processes related to these are governed in this sub-programme. As such, this sub-programme also oversees the creation and promotion of tourism products in partnership with, for example, local craftsmen and artists.

However, economic development in small towns may come with negative effects such as an increase in the cost of living , worker exploitation, increased light pollution, etc. While this document does not intend to provide ways of mitigating these effects, it is important to raise awareness on these issues and make an effort with local authorities to fight these.