OPENING MINDS:
RESEARCH FOR SUSTAINABLE
DEVELOPMENT

Challenges of Space Debris and Site Selection Criteria to Install Optical Telescope to Observe Space Debris in Sri Lanka

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1 INTRODUCTION

Since the Soviet Union launched the world's first artificial satellite, Sputnik 1, in 1957, thousands of satellites have been sent into space to orbit around the earth. Today, thousands of active satellites are in place in mainly Low Earth Orbit (LEO), Medium Earth Orbit (MEO), Geostationary Orbit (GEO) and High Earth Orbit (HEO).

The usages of satellite for different purposes include earth observation/remote sensing, communication, military, surveillance, navigation and earth science/meteorology, astrophysics, etc. All man-made satellites launched since 1957, which no longer serve a useful purpose are known as space debris. These space debris continuously collides with each other and starts a chain reaction that generates more junk. Their increasing growth has become a threat to the operational satellites and spacecraft. Even 1 cm space debris could cause severe damage to a valuable satellite with a force of a hand grenade. Aside from threatening satellites it poses a danger to a long-term orbital mission like the International Space Station, hence this situation could cause serious problems for future space launches.

Mitigation and removal are the main two ways to reduce space debris. Reducing the creation of new debris is known as "Mitigation", whereas "Removal" means amputating space debris either naturally or actively. Natural removal can occur by atmospheric drag and active removal can be by human-made systems. Trajectories, altitude and size of each and every space debris item must be analyzed for the active removal from human-made system. Space debris need to be detected and catalogued either using Radar or Optical measurements for the safety of operational satellites.

The main objective of this research paper is to identify the most suitable site to establish a new Optical Telescope to initiate space debris observation in Sri Lanka. Five convenient locations were selected. The target is to identify the optimist location to fix the Optical Telescope, while evaluating all five locations under the Technical, Infrastructure, Incentive and Financial factors. With the use of an Optical Telescope debris can be detected when the debris object is in the sunlight while the sky background is dark. The project planned to observe debris in geosynchronous orbit because the observation can continue during the entire night. Debris at LEO are the closest to earth, but difficult to concentrate because observation period is limited to an hour or two just after sunset or before sunrise.

These facilities can be used to observe asteroids, which are harmful to the earth and minor planets also.

2 METHODOLOGY

Sri Lanka is divided into three climate zones base on rainfall. These climate zones are designated as Wet zone, Dry zone and Intermediate zone. Five convenient locations were selected in order to choose the best location to establish an observatory for the proposed optical observation for searching space debris. Three sites were from the Dry zone and two sites from Intermediate zone. Among the selected sites, three sites are situated at national universities and the other two sites situate at national wildlife parks. Namely the sites are Rajarata, Wayamba, Sabaragamuwa universities, Maduruoya and Wilpattu.

The main objective is achieved based on the available literatures, data sets and gathered information from the astronomers and educated civilians at the selected locations.

Based on the literature the present study has identified four key areas to be assessed in the locations using the data collected by various methods. They are, "Technical factors" extended by the main technical requirement for optical observations, the "Infrastructure factors" available infrastructure to establish an observatory easily, the "Incentive factors" pertaining to acquisition of land and requirement of human resources to carry out continuous optical observations and "Financial factors" to build up the observatory and continuous operation and maintenance cost. Finally, analysis of all factors led to the selection of the best site to establish the optical observatory for the space debris observations.

Data captured through various methods was tabulated and then were ranked using a qualitative classification having four class groups identified as Threshold (Very High), High, Medium and Low. The qualitative classification of the quantitative data captured was judgmental. Past experiences were also utilized for the assessment of each and every site.

Each class identified as Threshold, High, Medium and Low was then assigned a numerical value as 5, 3, 2, and 1, respectively. This enabled the identification of corresponding percentages indicators ranging from 0 - 100%.

3 RESULTS AND DISCUSSION

Fourteen sub factors were considered under the four main factors to find a suitable location to establish an optical telescope observatory to initiate space debris research in Sri Lanka. Past as well as the most recently available data of different five sites were carefully analysed.

Annual rainfall, clear night, particle scattering and light pollution were considered under the Technical Factors.

Table 1: Figures which has considered under the technical factors

	Annual Rainfall (mm)	Clear Night/Year	Light Pollution (10^{-9} W/cm^2 * sr)	Annual Temperature Variation (^{O}C)
Rajarata University	1200	High	1.5	4
Wayamba University	1400	High	1	4
Maduruoya	1600	Very High	0.3	4
Wilpattu	1200	Very High	0.7	4
Sabaragamuwa University	2300	Moderate	1	4

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In 2011 the US National Oceanic and Atmosphere Administration (NOAA) launched the Suomi NPP satellite with camera called Visible Infrared Imaging Radiometer Suite (VIIRS). Using these data they published Light Pollution Map of the world. The light pollution data of the selected areas were calculated from this map.

Sri Lankan climate mainly depends on the monsoon and the rainfall pattern, the number of photometric cloudless sky condition directly related with the monsoon season. For astronomers, amateur or professional, the percentage of photometric nights is a key factor when deciding where to build an observatory for optical observations. The temperature differs slightly depending on the seasonal movement of the sun in Sri Lanka and particle scattering is not a key factor for space debris observation. Artificial light at night is one of the key factors influencing optical observations. Willpattu and Maduruoya sites are the best places considering only Light Pollution maps. With the consideration of Technical Factors the best place is Wilpattu to establish the new observatory to initiate space debris observations. The second best place is Maduruoya and third best place is Rajarata University.

Site selections for the telescope become more complex with consideration of infrastructure, incentive, and financial factors. Security, road, power and internet facilities were considered under the Infrastructure Factors. Security becomes an added issue and important for the operation of any observatory. If the observatory situated in the national park the situation becomes worse and it is necessary to take actions to protect observatory from wild animals. Road access facilities and internet coverage are not available at the Maduruoya and Wilpattu sites while readily available at the other three sites situated at the national universities. New roads have to be constructed if either Maduruoya or Wilpattu is selected.

Electric Power is another most essential key factor for the operation of the research equipment and other infrastructure requirements. Power is not available at the national wild life parks sites situated at Maduruoya or Wilpattu, and it would require alternative energy sources to generate electricity. Possible alternative energy sources are either solar or environment friendly low noise generator to fulfil the power requirement of the observatory. All sites at national universities have electric power facility.

With the consideration of infrastructure factors good sites are Rajarata University, Wayamba University and Sabaragamuwa University, to establish a new observatory to initiate space debris observations. Maduruoya and Wilpattu sites represent very low rank for infrastructure availability.

Acquisition of land, disasters, accommodation for observers and maximum usage possibility were considered under the Incentive Factors.

Allocation of land to build an observatory at the wild life conservation national park is extremely difficult, as national parks are reserved by the government of Sri Lanka for conservation of wildlife heritage for present and future generations.

Sri Lanka is mostly affected by natural disasters. Floods are mostly due to monsoonal rain. Wilpattu site is flooded during monsoon seasons. Buildings and other infrastructures must be built considering the flooding situation. Lodging facilities for observers is also very important. If a site selected to build observatory is at national park, food, accommodation and transport for observers is a big challenge. There are no such challenges if the site is situated at any university premises.

Present government promotes research with collaboration of government sector, universities and private sector. This project plans collaborate with the International Scientific Optical Network (ISON), Russia and one of the national universities in Sri Lanka. Hence this is a great opportunity to involve in international research for university students in Sri Lanka. Rajarata University is conducting B.Sc. - 4 year degree in Chemistry and Physics. Sabaragamuwa University is conducting B.Sc. (Applied Sciences) Special Degree in Applied Physics (4 years). The students of these two universities and other interested university students can get involved for the research if the observatory is situated within a university.

Rajarata University or Sabaragamuwa University is the best site considering incentive factors.

Initial cost, operation and maintenance is high if the observatory is to be built at either Maduru oya or Wilpattu national parks. The cost is comparably low if the site is to be built at any site in either of the national universities.

Most of the developed countries have built optical observatories to observe space debris managing the light pollution. Light pollution is worse in developed countries than in Sri Lanka. One best example is the Bisei Spaceguard Center, Bisei, Japan where the light pollution is 1.5 x 10 -9 W/cm2 * sr, which isvery similar to Rajarata University or Sabaragamuwa University, Sri Lanka. One of the main objectives of the Bisei Spaceguard Center is to discover new asteroids and space debris. Zimmerwald Observatory, Switzerland where the light pollution is 3 x 10 -9 W/cm2 * sr, which is used for searching minor planets and space debris.

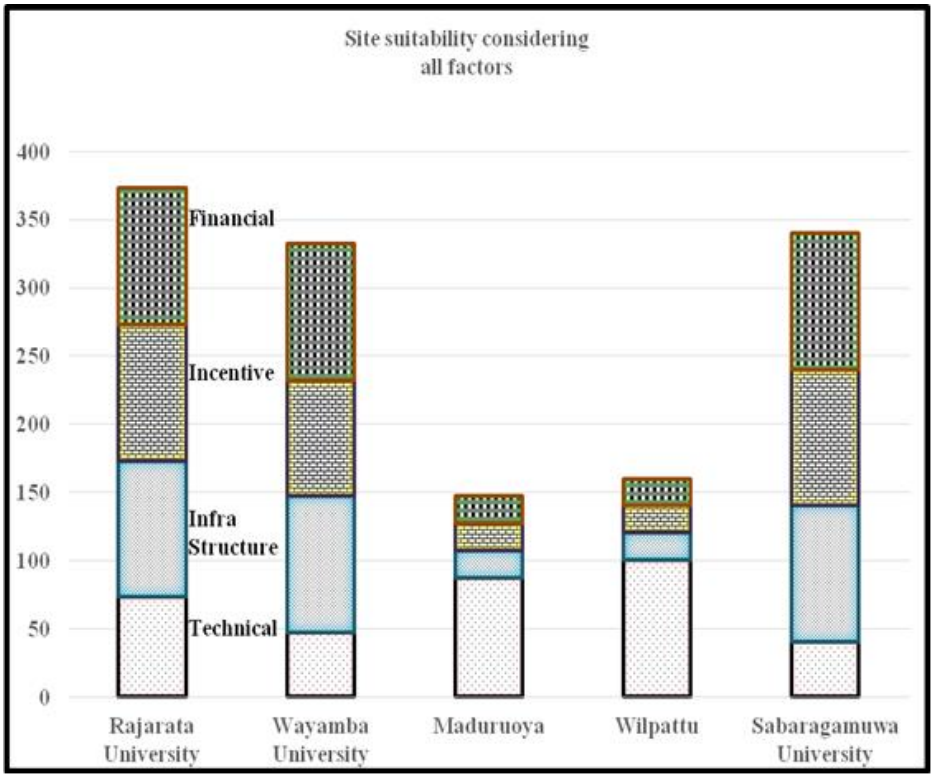

Figure 1: Rank of selected locations considering all fourteen Factors

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4 CONCLUSIONS AND RECOMMENDATIONS

Deterioration of space environment with space debris is becoming a serious problem. To protect active satellites in orbits, space debris must be precisely monitored before taking any actions for its removal. Ground based telescope can detect GEO debris down to 10 cm in size and can be analysed based on the trajectories and altitude of GEO debris.

To select the most suitable location to install an optical telescope is very important and more complex when considering Technical, Infrastructure, Incentive and Financial factors for the selected three locations from Dry Zone and two locations from Intermediate Zone in Sri Lanka. Three locations are situated at national universities, which are Rajarata, Wayamba and Sabaragamu universities and other two locations are national wildlife parks which are Maduruoya and Wilpattu. This paper describes the methodology which was carried out for the site selection survey.

Considering all factors in qualitative and quantitative classification the best location is Rajarata University to establish an optical telescope for the observation/discovering the available or new asteroids / space debris or minor planets. The second best location is Sabaragamuwa University. Figure 1 indicates the rank of selected locations considering all fourteen factors.

REFERENCES

Burt, T.P. and Weerasinghe, K.D.N. (2014). Rainfall Distributions in Sri Lanka in Time and Space: An Analysis based on Daily Rainfall Date. Climate ISSN 2225-1154.

Cowles, K. (1989). Site Selection Criteria for the Optical Atmospheric Visibility Monitoring Telescopes. TDA Progress Report: 42 – 97.

Department of Meteorology, Sri Lanka.

Dialog 4G Coverage map. http://www.dialog.lk/4g/

Light Pollution Map. https://www.lightpollutionmap.info/

Sri Lanka Telecom Mobitel 4G Coverage map. http://www.mobitl.lk/coverage

Stack, J. (1964). Procedures for location of astronomical observatory sites. International Astronomical Union, Symposium no. 19, Paris.

The World Bank group Climate Change Knowledge Portal. http://sdwebx.worldbank.org/climateportal/

Wijesekara, N.T.S. and Peiris, T. Chandana. (2008). The Status of RS/GIS/GPS Applications in Sri Lanka: A Survey of Public, Private and Non- Governmental Organisations. The Institution of Engineers, Sri Lanka. Engineer – Vol XXXXI, No. 05: 5 – 17.