George Profitiliotis, SDG 15 Life On Land

Abstract

Sustainable development is usually defined as the development that meets the needs of the present equitably, without compromising the ability of future generations to meet their own needs. Sustainable development is viewed as a principle with three pillars: the natural environment, human society, and the economy.

The 17 United Nations Sustainable Development Goals (SDGs) are directly related to these pillars. Space is an enabler that can contribute to the implementation of the SDGs, as the utilization of space assets can accelerate the transition towards a sustainable development paradigm.

In particular, space-related assets are invaluable in achieving the realization of SDG #15, Life on Land. Not only remote sensing and geolocation are already providing a powerful infrastructure to monitor and assess the extent of deforestation, desertification, and biodiversity loss, but also other novel technologies developed for living in space -such as controlled and efficient greenhouses, and technologies for reclaiming resources from waste and for cultivating useful microorganisms- can prove catalytic and decisive in preventing and reversing these deteriorating phenomena in the future. These technologies are already maturating; a proper knowledge transfer strategy may be able to accelerate their application in addressing some of the most pressing sustainability issues of our time.

Article

Sustainable development is usually defined as the development that meets the needs of the present equitably, without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). Sustainable development is viewed as a principle with three pillars: the natural environment, human society, and the economy. The 17 United Nations Sustainable Development Goals (SDGs) are related to these pillars and should be achieved by every country by the year 2030 (United Nations, 2015). Space is an enabler that can contribute to the implementation of the SDGs, as the utilization of space assets can accelerate the transition towards a sustainable development paradigm (UNOOSA, 2019). Satellite telecommunication systems can facilitate the global connections that are needed for worldwide communication and cooperation. Satellite timing and navigation can provide accuracy and precision to better integrate local and global observation of moving assets, animals, and people. Earth observation and remote sensing can augment our ability to understand and monitor the evolution of natural and manmade systems, in both the local and global dimensions. Research in Low Earth Orbit is already leading the discovery of novel chemical, pharmaceutical, and biomedical materials that make our lives better.

Particularly, space is already contributing to SDG #15, Life on Land. There are three main aspects of SDG #15: manage forests, preserve biodiversity, and combat desertification (United Nations, 2019). The most widely-used space asset utilized in these cases is remote sensing and geolocation. Remote sensing is a powerful tool, used to detect, quantify and monitor the degradation of forests (Mitchell, et al., 2017), and to assess land cover change (Beuchle, et al., 2015) and the temporal dynamics of how desertification is propagating (Han, et al., 2015). It is also being used to monitor and track other phenomena that cause or result from deforestation and desertification, e.g. in (Fensholt, et al., 2013). Remote sensing and satellite-based geolocation can also be used to track the changing patterns of biodiversity, both plant (Asner & Martin, 2016) and animal (Urbano, et al., 2010) life. The fusion of space-originated data is usually accomplished through the use of Geographic Information Systems (Wang, et al., 2010).

In the future, space-related research may also contribute to the mitigation or reversal of the phenomena of forest and land degradation and the resulting biodiversity loss. With respect to the mitigation of these phenomena, research has shown that, in some cases (Faiza, et al., 2017), deforestation and land degradation is occurring in developing countries because of the rising need for agricultural and grazing land, among other causes (e.g. commercial wood exploitation). Controlled-environment agriculture greenhouses that have been primarily developed for growing food in future space stations (Meinen, et al., 2018) could help alleviate this problem, without inequitably stressing the underprivileged societal groups. State-of-the-art innovations in soil-less cultivation systems that have been tested in space, e.g. in (Shen, et al., 2018) and (Massa, et al., 2016), have shown that outward land expansion is not necessary for modern hydroponic, aeroponic, and aquaponic agriculture (Goodman & Minner, 2019): human food and animal feed can be grown in efficient conditions, in terms of usable volume, as well as energy, nutrient, and water footprint. Vertical farming is already gaining momentum around the world (Beacham, et al., 2019): plant biomass can be cultivated under artificial light, on specially designed substrates, with the use of precisely composed nutrient solutions; all these parameters can be controlled to achieve maximum yield, without the limiting factors of uncontrollable microclimate and weather events, of day-night cycles, and of pests and plant diseases. By an appropriate technology transfer of these technologies (Stevens & Shaikh, 2018) to farming use cases in developing countries, the anthropogenic pressure on forests and the over-exploitation of land for the production of human food and animal feed may be halted, and biodiversity may be preserved, thanks to the protection of habitats and ecological niches.

Regarding the reversal of these deteriorating phenomena, current research in experimental astrobiology (Boland, 2018) and bio-regenerative space life-support systems (Escobar & Nabity, 2017) is generating new knowledge with respect to the interactions of living organisms with geochemical processes. Man-made Biological Soil Crusts have been proposed as a possible engineering solution to accelerate the process of degraded land restoration (Meng & Yuan, 2014); a process that would otherwise take a much longer time, if left to purely natural forces (Lababpour, 2016). The Biological Soil Crust is one of the most vital components of the soil: namely, it is the outer, cohesive, thin, horizontal ground cover which is formed by a consortium of microorganisms at the soil surface (Chiquoine, et al., 2016). Man-made Biological Soil Crusts based on microalgae seem to provide an excellent first base on desertified land, upon which the restoration can proceed further (Uysal, et al., 2015). Thus, through ecological succession, even a forest could be able to be gradually restored. Space research on the biological recycling of wastes and the biological utilization of in-situ available space resources via the use of microalgae and microbial consortia could be utilized in the production of biofertilizer from peri-urban waste streams (Lasseur, et al., 2010) and in the cultivation of the necessary terrestrial microalgae that will inoculate the soil (Verseux, et al., 2016). The combined use of waste-to-fertilizer and microbial biotechnology developed for human spaceflight could prove beneficial in regenerating degraded lands on Earth and restoring lost biodiversity.

In conclusion, space-related assets are invaluable in achieving the realization of SDG #15, Life on Land. Not only remote sensing and geolocation are already providing a powerful infrastructure to monitor and assess the extent of deforestation, desertification, and biodiversity loss, but also other novel technologies developed for living in space -such as controlled and efficient greenhouses, and technologies for reclaiming resources from waste and for cultivating useful microorganisms- can prove catalytic and decisive in preventing and reversing these deteriorating phenomena. These technologies are already maturating, and a proper knowledge transfer strategy may be able to accelerate their application in addressing some of the most pressing sustainability issues of our time.

Bibliography

Asner, G. P. & Martin, R. E., 2016. Spectranomics: Emerging science and conservation opportunities at the interface of biodiversity and remote sensing. *Global Ecology and Conservation*, Volume 8, pp. 212-219.

Beacham, A. M., Vickers, L. H. & Monaghan, J. M., 2019. Vertical farming: a summary of approaches to growing skywards. *The Journal of Horticultural Science and Biotechnology*, 94(3), pp. 277-283.

Beuchle, R. et al., 2015. Land cover changes in the Brazilian Cerrado and Caatinga biomes from 1990 to 2010 based on a systematic remote sensing sampling approach. *Applied Geography*, Volume 58, pp. 116-127.

Boland, E., 2018. *NIAC Phase I Grant "Mars Ecopoiesis Testbed". NNX14AM97G Final Progress Report*, Greenville, Indiana: NASA.

Chiquoine, L. P., Abella, S. R. & Bowker, M. A., 2016. Rapidly restoring biological soil crusts and ecosystem functions in a severely disturbed desert ecosystem. *Ecological Applications*, 26(4), pp. 1260-1272.

Escobar, C. & Nabity, J., 2017. *Past, present, and future of closed human life support ecosystems-a review.* Charleston, South Carolina, 47th International Conference on Environmental Systems, 16-20 July 2017.

Faiza, N., Weiguo, J., Aijun, Y. & Wenxing, S., 2017. Giant deforestation leads to drastic eco-environmental devastating effects since 2000; a case study of Pakistan. *The Journal of Animal & Plant Sciences*, 27(4), pp. 1366-1376.

Fensholt, R. et al., 2013. Assessing land degradation/recovery in the African Sahel from long-term earth observation based primary productivity and precipitation relationships. *Remote Sensing*, 5(2), pp. 664-686.

Goodman, W. & Minner, J., 2019. Will the urban agricultural revolution be vertical and soilless? A case study of controlled environment agriculture in New York City. *Land Use Policy*, Volume 83, pp. 160-173.

Han, L., Zhang, Z., Zhang, Q. & Wan, X., 2015. Desertification assessments in the Hexi corridor of northern China's Gansu Province by remote sensing. *Natural Hazards*, 75(3), pp. 2715-2731.

Lababpour, A., 2016. Potentials of the microalgae inoculant in restoration of biological soil crusts to combat desertification. *International journal of environmental science and technology*, 13(10), pp. 2521-2532.

Lasseur, C. et al., 2010. MELiSSA: the European project of closed life support system. *Gravitational and Space Research*, 23(2), pp. 3-12.

Massa, G. D., Wheeler, R. M., Morrow, R. C. & Levine, H. G., 2016. Growth chambers on the International Space Station for large plants. *ISHS Acta Horticulturae*, Volume 1134, pp. 215-222.

Meinen, E., Dueck, T., Kempkes, F. & Stanghellini, C., 2018. Growing fresh food on future space missions: Environmental conditions and crop management. *Scientia horticulturae*, Volume 235, pp. 270-278.

Meng, X. & Yuan, W., 2014. Can Biochar Couple with Algae to Deal with Desertification?. *Journal of Sustainable Bioenergy Systems*, 4(3), pp. 194-198.

Mitchell, A. L., Rosenqvist, A. & Mora, B., 2017. Current remote sensing approaches to monitoring forest degradation in support of countries measurement, reporting and verification (MRV) systems for REDD+. *Carbon balance and management*, 12(9), pp. 1-22.

Shen, Y. et al., 2018. Research on lettuce growth technology onboard Chinese Tiangong II Spacelab. *Acta Astronautica*, Volume 144, pp. 97-102.

Stevens, J. D. & Shaikh, T., 2018. *MicroCEA: Developing a Personal Urban Smart Farming Device.* Kuala Lumpur, Malaysia, IEEE, 2nd International Conference on Smart Grid and Smart Cities (ICSGSC), 12-14 August 2018.

United Nations, 2015. *The Sustainable Development Agenda: 17 Goals to Transform Our World.* [Online]
Available at: https://www.un.org/sustainabledevelopment/development-agenda/
[Accessed 26 / 4 / 2019].

United Nations, 2019. *SDG 15 Life on Land: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.* [Online] Available at: https://www.un.org/sustainabledevelopment/biodiversity/ [Accessed 26 / 4 / 2019].

UNOOSA, 2019. *Benefits of Space for Humankind.* [Online] Available at: http://www.unoosa.org/oosa/en/benefits-of-space/benefits.html [Accessed 28 / 4 / 2019].

Urbano, F. et al., 2010. Wildlife tracking data management: a new vision. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365(1550), pp. 2177-2185.

Uysal, O., Uysal, F. O. & Ekinci, K., 2015. Evaluation of microalgae as microbial fertilizer. *European Journal of Sustainable Development*, 4(2), pp. 77-82.

Verseux, C. et al., 2016. Sustainable life support on Mars – the potential roles of cyanobacteria. *International Journal of Astrobiology*, 15(1), pp. 65-92.

Wang, K., Franklin, S. E., Guo, X. & Cattet, M., 2010. Remote sensing of ecology, biodiversity and conservation: a review from the perspective of remote sensing specialists. *Sensors*, 10(11), pp. 9647-9667.

World Commission on Environment and Development, 1987. *Our Common Future.* Oxford: Oxford University Press.