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## Earth observation education for Zero Hunger: A Massive Open Online Course towards achieving SDG #2 using EO

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### Abstract

Persisting hunger and malnourishment continue to be a problem of global concern, which recent climate change, as well as environmental and socio-economic crises and their impacts along the food chain further exacerbate. Earth observation (EO) holds the capacity to deliver large temporal and spatial coverage information that allow for better decision-making in food production and distribution. Furthermore, the rapidly increasing amount of freely available data and tools potentially enable an expanding user community to bring this information into practice. However, more people need access to EO education to realize this potential. EO Connect (funded by the German Ministry of Education and Research) addresses this demand by developing a Massive Open Online Course (MOOC) towards the UN Sustainable Development Goal (SDG) 2: Zero Hunger. Since a conventional course can barely reflect the comprehensiveness of SDG #2 regarding both content and the people involved in achieving the goal, the Zero Hunger MOOC leverages modern learning approaches in a non-linear, adaptive learning environment to cater to a large audience and diverse target groups, and to their different scopes and levels of desired learning outcomes. The use of micro-content, drip-feeding and feedback-guided course development shall ensure maximum effectiveness. To accomplish this ambitious endeavour, the Zero Hunger MOOC is developed with a community of stakeholders from the realms of EO, education, information technology, and food security. It builds on contents from this community which are adapted, streamlined and assembled to course modules, as well as on the expertise from the over 20 contributing universities, space agencies, national institutions and international organizations. While the Zero Hunger MOOC contributes to bridging the gap between the available EO technology and its application to increase food security, it likewise promotes stronger stakeholder connection in EO education.

### Keywords

SDG #2, Zero Hunger, MOOC, networking, community building

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## Acronyms/Abbreviations

EO	<i>Earth Observation</i>
FAO	<i>Food and Agriculture Organization of the United Nations</i>
MOOC	<i>Massive Open Online Course</i>
SDG	<i>Sustainable Development Goal</i>

## 1. Introduction

In 2015, the United Nations defined 17 goals towards sustainable development to be reached by 2030. Sustainable Development Goal (SDG) #2 is dedicated to “End[ing] hunger, achiev[ing] food security and improved nutrition and promot[ing] sustainable agriculture” [1]. The world has made progress in reducing global hunger over the past decades and there is evidence that our food supply systems can adapt to the challenges of meeting future food demands. Yet, over 800 million people still suffer from hunger and 2 billion are malnourished [2]. And after some decades of steady decline in hunger, the uptick since the middle of the last decade uncovers the unvarnished vulnerability of food systems to climate and societal shocks [ibid.].

Earth observation (EO) has the potential to support food security by providing large temporal and spatial coverage information that allow for better planning and decision-making in food production and distribution. But while we are witnessing a dramatic increase in the volume of freely available EO data and in the number of open EO tools, insufficient diffusion of EO technology from the space to the user communities impedes its adoption to its full potential [3]. EO education helps to put EO technology into practice [3] and thus contributes to the adoption of EO technology in support of food security [4]. Due to its flexibility, reach and didactic possibilities, digital learning has proven to be a valuable instrument to promote learning for sustainable development [5] and even more in times of restricted access to formal education since the COVID-19 pandemic [6].

Stakeholders from academia, space agencies, institutions and organizations increasingly make their training materials available online at no cost. They thus acknowledge the need for open EO learning materials while sharing their instructional design and content with the EO educator community, promoting the synergies that strong communities yield. Through the contest “CONNECT Education-Research-Innovation”, the German Federal Ministry of Education and Research is funding five projects that work towards strengthening international

cooperation in research and extending existing networks around innovative nucleus projects. EO Connect is one of the winning CONNECT-FIVE projects. It addresses the rapidly growing demand for low-barrier access to EO knowledge and applied skills for food security by developing a Massive Open Online Course (MOOC) towards SDG #2, hereafter referred to as the Zero Hunger MOOC. It uses the advantages of knowledge and learning material exchange across EO educator networks, likewise strengthening and widening the networks. Its objectives are:

- to develop a MOOC on the role of EO for the Zero Hunger Goal,
- to strengthen the EO educator community around this joint effort.

## 2. Dissemination of EO-based approaches towards SDG #2

### 2.1. EO education for food security

The capacity of EO-based approaches to support reporting towards the SDGs and to inform decision-making and planning for increased food security is widely recognized as it provides consistent, timely and disaggregated data at comparatively low cost [7]. The Food and Agriculture Organization of the United Nations (FAO) defines food security as a state where “all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life” [8]. This definition reflects the multi-dimensionality of food security. A plethora of EO-based approaches around food security exists and can mostly contribute information at the supply side of food systems. Food production plays a crucial role for food security outcomes. Therefore, the Zero Hunger MOOC shall cover the food production system categories agriculture, livestock, forestry and fishery.

MOOCs enable large-scale teaching beyond traditional teacher-learner environments, where massive refers to the reach and basically unlimited learner participation and open to the accessibility of the resources [9]. These characteristics make MOOCs particularly relevant in the context of a global goal such as Zero Hunger. EO-based approaches that can contribute to food security are numerous and so is the number of fields where learners can make use of them. To account for this heterogeneity, the Zero Hunger MOOC shall furthermore leverage modern learning approaches like non-linear learning, and use micro-content and drip-

feeding, which are particularly effective for reaching applied learning goals in a practical setting [10]. Thus, the MOOC shall cater to the diverse needs of the large target audience, and offer the possibility to select different learning paths according to their scopes and levels of desired learning depth.

## 2.2. Target group definition

To design a course, defining its audience is key. However, if every person involved in the global food system is a potential beneficiary of the Zero Hunger MOOC, the target audience become highly heterogeneous with respect to their background, knowledge and motivation. Based on fictitious personas, we identified three distinct target groups:

- Group 1: Persons who are technology proficient, sufficiently equipped and seek to use EO data for their work
- Group 2: Persons seeking EO-derived information for personal or business decisions (e.g., optimization of fertilizer application), but who are unlikely to start processing EO data because of technical constraints or because of low cost-efficiency
- Group 3: Persons in key positions in the public or private sector, wanting to get familiar with the capabilities of EO-based approaches for decision-making

The target groups serve to facilitate communication and idea exchange. They are useful in defining learning paths, desired learning outcomes, foreseeing challenges, and validating finished modules. Group 1 is likely to draw the most direct benefit from the Zero Hunger MOOC and therefore served as the focus target audience.

## 3. Stakeholder community building around the Zero Hunger MOOC

### 3.1. Activating stakeholders and organizing collaborative work

At the start of the conceptualization phase of the Zero Hunger MOOC, a call to action was launched to make potential collaborators aware of the opportunity to join forces towards the Zero Hunger MOOC. The call was shared in existing networks including people with whom previous or current formalized project work was conducted, research collaborators, institutions with previous or ongoing in-kind activities, formalized networks, key persons at institutions, former colleagues and students. Therefore, most respondents were from the closer existing networks, but also included stakeholders

without previous collaboration. This initial call already resulted in the registration of around 20 interested stakeholders.

During the following meetings, we pitched the MOOC draft concept and created space for experience and idea exchange among the potential collaborators from academia, public and private sector. Afterwards, we created a database of our own learning materials and the ones stakeholders wanted to contribute. Work was further organized through a collaborative whiteboard with the following categories: Content and learning goals, available materials, personas and respective challenges, stakeholder areas of expertise, and learner feedback options. This board enables continuous collaboration and provides transparency to the stakeholders.

### 3.2. Defining a common language

To ensure efficient collaboration, we had to define a common language. In terms of how to speak about the role of each collaborator, we defined the following main tiers of collaboration, which exist in combination and may change over time:

- Tier 1: Stakeholders who contribute learning materials and give feedback on the modules they contribute to
- Tier 2: Stakeholders who engage in knowledge exchange on the course's instructional design or act as experts or resource persons on specific EO or food security-related topics
- Tier 3: Stakeholders who endorse the course and provide their own networks to promote the MOOC

Tier-1 collaborators provide a wide range of different materials, from literature to videos, quizzes and tutorials. A simplified typology based on the actual contributions is presented in Table 1. Sources are usually text-form materials stakeholders recommend for specific EO and food security topics. They provide context and content for MOOC modules rather than didactic elements. Type-I and Type-II learning materials include content and didactic elements with or without the intention of use outside of the teaching environment. The most complex type of contribution is a full course, which is self-contained and comprehensive for a specific topic. The material type has direct implications on how content is used to create MOOC modules.

Type-I and Type-II materials are often easy to embed in the module context, although the quality differs. In contrast, sources require

didactic preparation. Full courses that can span hours of learning have to be dissected to extract individual elements. All materials need to be arranged and streamlined to fit the module's learning goal, as well as adapted to a common Zero Hunger MOOC layout. Available content is shortened or expanded by additional content to fill gaps. It is critical to share how the materials are adjusted, complemented, referred to with the stakeholders, and how they acknowledged.

**Table 1. Simplified learning material typology**

Material type	Description
Source	Mostly text-form materials as suggested or curated by the stakeholder; e.g., research articles, reports, policy briefs
Learning material - Type I	Digital learning materials created without the explicit intention of reusing them outside the original teaching environment; e.g., university course tutorials, vocational training materials
Learning material - Type II	Digital learning materials created with the primary or secondary aim of making them available outside the original teaching environment; e.g., webinars, workshop recordings
Full course	E-learning courses or other high-end self-contained materials, often hosted on specific platforms or downloadable as standalone products; e.g., MOOCs

#### 4. Development of the Zero Hunger MOOC content

##### 4.1. Mapping available resources

To define the MOOC outline, we followed a two-pronged approach. On one side, we defined our expectations on what should provide based on literature research and on the personas. On the other side, we mapped the provided and potential further open learning resources. Then, we overlaid them to refine the MOOC outline.

Mapping and describing the resources on the collaborative whiteboard crystallized into clusters around food production systems, hazards, basics of remote sensing, and climate as a potential impact on each production system. Since many materials belonged to multiple categories, we assigned tags to them. Tag categories are, for example, background and tutorial, the food production systems, optical and radar imagery, tools, specific sensors etc. This approach also allowed simulating possible learning paths through the mapped materials.

##### 4.2. Shaping course modules

The course has a modular structure which allows learners to choose the entry point and thematic focus. It is designed as a sequence of shorter modules which offers different learning paths and uses the advantages of micro-learning. The more modules are released, the more can learning paths differ and the more can learners be supported with adaptive learning, e.g., through a recommender system. The modules are defined based on the mapped learning resources at the intersection of the food production systems and the target audience, paying special attention to transferring knowledge and technical skills around the SDG #2 targets and indicators. How much content should be released around which food production practice is evaluated from the available resources, but also from their representation in a selection of relevant publications and conferences.

Interaction of stakeholders and the core team on and learner feedback shall guide course development and thus help optimize the content and the didactic form in which it is provided. The stakeholders who provide content for a module as well as stakeholders that act as experts in the respective field are consulted before it is released (Tier-1 and Tier-2 collaboration). In contrast, learner feedback is enabled post-release. Each module has a feedback section and possible other, more targeted learner feedback is envisaged to be gathered, the reaction to which is enabled by the flexibility of sequential module release. In combination with a user survey upon registration, this also serves as a monitor of whether the target audience is reached. In particular in the beginning, Tier-3 stakeholders will contribute to reaching potential learners by disseminating the course through their networks.

#### 5. Discussion

##### 5.1. Collaborative course development

Figure 1 represents the Zero Hunger MOOC approach to course development. It accounts for the diverse factors that hamper, and the variety of EO-based approaches that support food security. It acknowledges the value of networks and the existence of available high-quality third-party learning materials with their potential to create new course materials based on them. Enhancing community building in EO and making learning resources extensively available, usable and reusable have become widely recognized goals in the EO landscape. All collaborating stakeholders were motivated

and positive about their contributions towards the MOOC. Yet, more non-conventional and often non-formalized collaboration entails challenges concerning interaction and technicalities.

When partners collaborate officially and formally, they discuss and define their roles before formalizing the collaboration. They also develop implicit knowledge on the partner's expectations and way of working throughout the process. In contrast, the explicit and implicit knowledge that regulates the collaboration does not exist per se in looser cooperation. This increases the risk of misunderstandings around the tasks, can lead to a loss of interest, reduced effort and eventually even to dropping out of the collaboration. In the case of the Zero Hunger MOOC, misunderstandings mostly revolved around the role and thus types of engagement and around which learning resources to share and how. Therefore, it proved to be a prerequisite to successful communication to develop a common terminology around these aspects.

On the technical side, some materials and logos needed clearance from other administrative levels or from responsible persons other than the Zero Hunger MOOC point of contact within an institution. In some instances, individual elements in full courses fell under the licensing of additional third parties, which complicated the access to the respective resources. Particularly when additional administrative levels or third parties not previously and directly involved are addressed, using the developed vocabulary simplified the communication. This finding is in line with other efforts to define common standards of communication on existing learning resources in order to facilitate exchange within the EO community.

### 5.2. *The Zero Hunger MOOC*

MOOCs cater to a large audience and are therefore well adapted to work towards a global goal. However, preparing a course around a complex topic and for heterogeneous learner groups with different backgrounds constitutes a big challenge. MOOC development can hence particularly benefit from approaches that differ from conventional linear course layouts. Smaller-sized content and freedom in choosing the learner journey according to the topics of interest and learning objective allows to customize the learning experience. Smaller adjustments to module design can then be made based on learner feedback to already released modules. To which extent the feedback can be integrated has yet to be tested.

Other challenges are related to working with available open online resources from our own previously released courses and from other stakeholders. Looking at and mapping out available resources showed that some categories were under-represented (e.g., EO and livestock, agroforestry). It was interesting to note that some resources were open, but still had access barriers to learners (e.g., outdated Flash course infrastructure or only temporary access to courses). To us, some had barriers like complicated procedures to get clearance for reuse or generally complex acknowledgement and permission regulations for different parts of existing courses. Moreover, although a large number of good learning materials was available, the effort of curating, reducing, expanding, assembling and streamlining them should not be underestimated.

## 6. Conclusions

Online learning yields unparalleled opportunities to disseminate EO knowledge and approaches around food security to users who can put it into practice. EO educators increasingly work towards providing learning resources to a large audience at no cost and towards establishing viable networks that render this dissemination more effective and efficient. The Zero Hunger MOOC as a common goal has shown to be a good occasion to signal willingness for collaboration on common topics within the course and beyond it. This can lead to solidifying existing relationships and can broaden the network for future formal and non-formalized collaborations, thus contributing to the community-building goal in EO education.

The Zero Hunger MOOC pilots a concept that values high quality third-party materials and the potential that non-linear learning and modern learning concepts offer. This is particularly beneficial in the case of a field as diverse as food security and heterogeneous user community. This work lays out a promising concept. In the next phase, parallel module development and module release with the incorporation of learner feedback will bring further insights and show how the concept translates into practice.

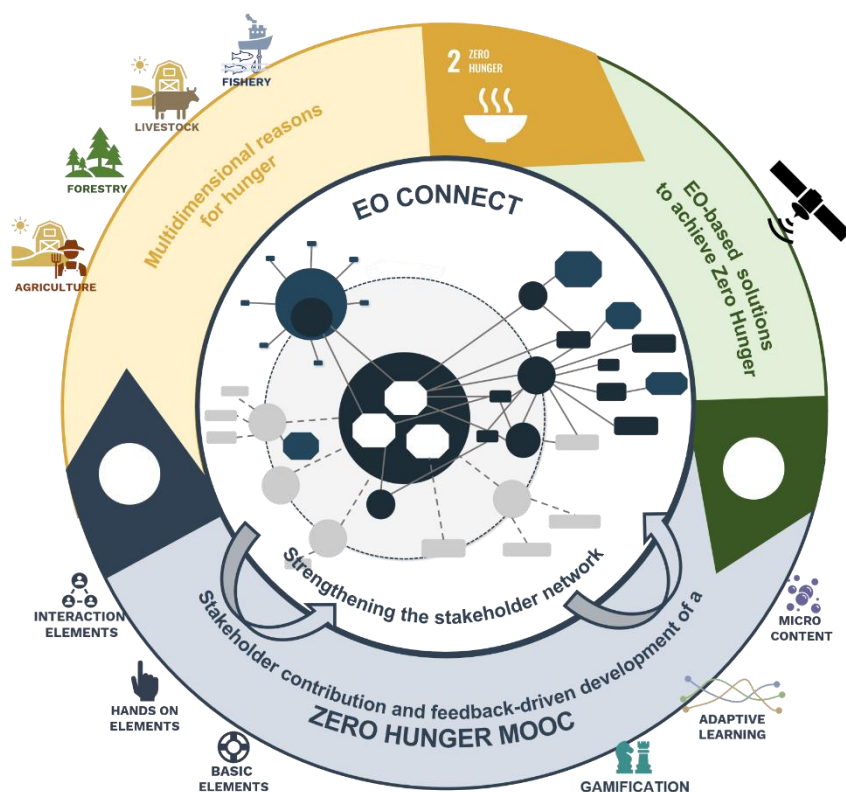
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## References

- [1] United Nations (UN), Transforming our World: The 2030 Agenda for Sustainable Development, A/RES/70/1, 2015.
- [2] FAO, IFAD, UNICEF, WFP and WHO, The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets, Rome, Italy, 2020.
- [3] T. Secara, J. Bruston, Current barriers and factors of success in the diffusion of satellite services in Europe, *Space Policy*, vol. 37, pp. 154–161, 2016.
- [4] A. I. Prados *et al.*, Impact of the ARSET Program on Use of Remote-Sensing Data, *IJGI*, vol. 8, no. 261, pp. 1–15, 2019.
- [5] M. G. Gómez-Zermeño, Massive Open Online Courses as a Digital Learning Strategy of Education for Sustainable Development, *J. sustain. dev. energy water environ. syst.*, vol. 8, no. 3, pp. 577–589, 2020.
- [6] R. Radha, K. Mahalakshmi, D. V. S. Kumar, D. A. Saravanakumar, E-Learning during Lockdown of Covid-19 Pandemic: A Global Perspective, *International Journal of Control and Automation*, vol. 13, no. 4, pp. 1088–1099, 2020.
- [7] M. Paganini *et al.*, Satellite Earth observations in support of the Sustainable Development Goals, Special 2018 Edition, p. 114, 2018.
- [8] R. Pérez-Escamilla, Food Security and the 2015–2030 Sustainable Development Goals: From Human to Planetary Health: Perspectives and Opinions, *Curr Dev Nutr*, vol. 1, no. 7, pp. 1–8, 2017.
- [9] M. M. Terras, J. Ramsay, Massive open online courses (MOOCs): Insights and challenges from a psychological perspective: Psychological perspective on massive open online courses, *Br J Educ Technol*, vol. 46, no. 3, pp. 472–487, 2015.
- [10] M. J. Dolasinski, J. Reynolds, Microlearning: A New Learning Model, *Journal of Hospitality & Tourism Research*, vol. 44, no. 3, pp. 551–561, 2020.



**Figure 1. Graphical representation of the Zero Hunger MOOC development concept accounting for different reasons for hunger, EO-based approaches, and the exchange of knowledge and learning materials across networks while leveraging the potentials of modern learning approaches such as the use of micro-content and gamification. The course will be hosted on the EO College platform (eo-college.org).**