



Research article



Development and Evaluation of Options for Action to Progress on the SDG 6 Targets in Austria

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ABSTRACT

The Agenda 2030 of the United Nations stipulates an ambitious set of 17 Sustainable Development Goals (SDGs). They were globally agreed upon and demand coherent, context-specific implementation at the national level. To address the complexity of challenges therein, the Agenda is designed to be integrated, indivisible, and universal. The numerous multifaceted interactions in-between the SDGs and with corresponding measures pose a complex challenge for decision-makers implementing them worldwide that requires support for a comprehensive discourse in the science-society-policy arena. Research on the interactions between the SDGs has been flourishing and can help to understand where policy options might be most successfully located. A catalytic effect on several other goals is, e.g., often attributed to SDG 6 on water and sanitation. However, beyond the *where* to locate policy options, it is similarly important to understand *how* potential policy options would affect the SDGs and their targets. We developed eleven options and 85 measures as context-specific pathways to advance the SDG 6 Targets in Austria. As a country in the Global North and with a generally far-established water and sanitation infrastructure and management, this responds to the Agenda's demand for universal applicability and can serve as an example to illustrate potential challenges beyond basic infrastructure provision and management. The proposed options cover resources-oriented sanitation, blue-green-brown infrastructure, efficient use and integrated management of water resources, maintenance and restoration of ecological functions of inland waters, reduction of diffuse discharge of nutrients and problematic substances as well as trace substances, water, sanitation and hygiene in public spaces, groundwater protection, development cooperation as well as co-design and co-creation. Their effects on the SDG 6 Targets are evaluated using a 7-point-scale. The evaluation method is simple and practicable, and fosters discourse on the entire water cycle amongst the expert group applying the method. The evaluated effects on the targets are found to be unanimously positive or neutral, but trade-offs might arise when including other SDGs in the assessment, making an expansion of the evaluation necessary for coherent implementation. The results can be used as a baseline to support follow-up discussions with stakeholders and decision-makers.

Abbreviations: SDG, Sustainable Development Goal; MDG, Millennium Development Goal; UN, United Nations; WASH, water, sanitation and hygiene; HEI, higher education institutions; UniNETZ, Universitäten und nachhaltige Entwicklungsziele (translation: Universities and Sustainable Development Goals); IWRM, integrated water resources management; ROS, resources-oriented sanitation; NBS, nature-based solutions; BGBI, Blue-Green-Brown Infrastructure; WWT, wastewater treatment; WFD, (EU) Water Framework Directive; LNOB, Leave no one behind; ODA, Official Development Assistance; MoI, Means of implementation.

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1. Introduction

With the Agenda 2030 and the corresponding 17 Sustainable Development Goals (SDGs) adopted in 2015, the United Nations (UN) envision universal sustainable development (United Nations, 2015) to overcome the multiple crises the world is currently facing: biodiversity is declining more rapidly than any time in human history (IPBES, 2019), climate change impacts are found to exceed previous estimations (IPCC et al., 2022), after a decade of progress in reducing poverty it is projected to rise again (Sumner et al., 2020) and global water scarcity (Boretti and Rosa, 2019; He et al., 2021) and the risk of associated hydro-political issues are expected to increase (Farinosi et al., 2018). These challenges are intertwined and complex, and so is the search for potential solutions that maximize synergies and minimize trade-offs at the same time (Horvath et al., 2022; Pham-Truffert et al., 2020). Addressing this complexity in the context of SDG 6 entails – as indicated by the corresponding targets – going beyond the mere provision of water and sanitation facilities to include the whole water cycle, integrated management, and the allocation of adequate means for implementation (UN Water, 2021). For coherent implementation, context-specific knowledge is found to be critical for the SDGs as a whole (Pham-Truffert et al., 2020) so as for SDG 6 in particular, as it is often managed at the national or subnational level (Di Vaio et al., 2021; Germann and Langergraber, 2022; Herrera, 2019).

So far, the global perspective is found to lead the knowledge on SDG interactions, bringing about a general lack of country-specific interactions to inform policy-making at the local level (Pham-Truffert et al., 2020). Adding to the plethora of national and local circumstances and challenges that need to be considered, an important normative evolution took place moving from the preceding Millennium Development Goals (MDGs) to the SDGs (Fukuda-Parr and McNeill, 2019): While the MDGs focused primarily on countries in the Global South, the SDGs call for universal applicability and demand countries of the Global North to take the lead (Fukuda-Parr and McNeill, 2019; Sachs, 2012; United Nations, 2015).

Besides their universal applicability and integrated manner, their indivisibility is one of the SDGs' characteristics emphasized in the Agenda 2030. As a consequence, a vast amount of research has been undertaken to understand the interactions between the SDGs and their targets (Horvath et al., 2022; Miola et al., 2019; Nilsson et al., 2016; Pham-Truffert et al., 2020; Weitz et al., 2018). While these interactions address the question of “*where policy intervention would be the most strategic to generate overall progress*” (Weitz et al., 2018, p. 547), they do not provide ad-hoc information on how specific policy interventions or measures impact the goals and targets. Several articles analyzed links between all or a set of SDG targets and action measures, such as, e.g., climate actions (Fuso Nerini et al., 2019; Gjorgievski et al., 2022), circular economy practices (Schroeder et al., 2019) or artificial intelligence applications (Mehmood et al., 2020).

Many authors attribute a particularly high amount of synergies with other SDGs (Alcamo, 2019; Fader et al., 2018; Jaramillo et al., 2019; Pradhan et al., 2017; Sustainable Sanitation Alliance, 2017a, Sustainable Sanitation Alliance, 2017b; UN Water, 2016) or even a “*catalytic effect*” (UN Water, 2021, p. 4) to SDG 6. With tremendous deficits in addressing the basic need for safe water, sanitation and hygiene (WASH) outlined in SDG 6 and the related Human Right to Water and Sanitation (UN Water, 2021; United Nations General Assembly, 2010), a doubtlessly important amount of scientific articles are focusing on the Global South (Herrera, 2019; Mycoo, 2018; Pereira and Marques, 2021) and emerging economies (Sarkar and Bharat, 2021). While research interests of the Global South and the Global North in the context of SDG 6 might overlap to some extent, relevant differences exist (Ho et al., 2020). Consequently, intensifying research that develops measures and systematically analyses their effects on the SDG 6 Targets also from the perspective of countries in the Global North is important to respond to the Agenda's demand for universal applicability.

For example, in Austria, while water and sanitation infrastructure as well as water governance and policies are widely in place and water availability is relatively high, challenges and deficits in the implementation of the SDG 6 Targets still exist. Yet, as scrutinized in Germann and Langergraber (2022), they are often not sufficiently covered by the globally defined indicators. A critical analysis of the SDG 6 Targets and indicators from the perspective of Austria shows that several problem areas can be identified, underlining the need to develop options for action in Austria. Challenges include diffuse pollution and the requirement to increase recycling rates of plant nutrients, hydro-morphological pressures on rivers, several habitat types being endangered or even under threat of extinction, a high virtual water footprint, inclusive water and sanitation facilities in public spaces, sufficient means for infrastructure investments to secure water and sanitation provision for the future, participation and international cooperation (Germann and Langergraber, 2022). Particularly the first five align with findings of O'Neill et al. (2018), who illustrate, that for many countries of the Global North the main challenge to reach sustainable development will be to find strategies to reduce resource use so as not to transgress planetary boundaries while maintaining or improving social thresholds.

Yet, the role of science in this context goes beyond the critical reflection of the SDGs, targets, indicators and the corresponding challenges. Universities and higher education institutions (HEI), in general, are found to have a unique role as “*agents for change*” towards sustainable development, particularly in stimulating the science-society-policy dialogue (El-Jardali et al., 2018; Gratzer et al., 2019; Radinger-Peer and Pflitsch, 2017; Stephens et al., 2008). Life sciences universities are being specifically challenged to take their role due to several reasons: they historically have a focus on the water-food-energy nexus and correspondingly strong relations to various SDGs, their links with regional, external actors and practitioners are traditionally well-established, and they can provide demanded expertise in using integrative approaches (Gratzer et al., 2019). By providing context-specific policy-relevant evidence, HEI can actively support decision-making. Indeed, they are urged to shift to “*actively shaping better policies and actions in support of the SDGs*” (El-Jardali et al., 2018, p. 4), emphasizing the need for scientific support to draft options to achieve the SDGs (Körfgen et al., 2019).

The framework of this research is a project called UniNETZ - Universitäten und nachhaltige Entwicklungsziele (translation: Universities and Sustainable Development Goals; “Uni” being short for Universities and “Netz” German for net) (Stötter et al., 2019; UniNETZ, 2022). In response to the HEIs role as change agents, the project aims are to strengthen interactions between science, policy and society, to intensify interdisciplinary cooperation between universities and research institutions as well as to contribute to sustainable development in general. To this end, sustainable development shall be integrated in research and education, and a set of “*policy relevant but not prescriptive*” (Körfgen et al., 2019, p. 7) options for action to implement the SDGs in Austria for decision-making support is developed (Körfgen et al., 2019; Stötter et al., 2019).

In this article, we illustrate the development of options and corresponding measures for SDG 6, present and discuss them and assess their effects on the eight SDG 6 Targets. The aim is not only to demonstrate potential options for actions to support policy-making but to elaborate in detail how these options and measures can advance the SDG 6 Targets in Austria and draw implications for the international research community. A manual for the methods applied and the options developed are published in German as part of the project report (Allianz Nachhaltige Universitäten und Österreich, 2021; Horvath et al., 2021). The paper presented here expands findings of the project by elaborating in-depth on the evaluation of the measures as a basis for the evaluation of the options, placing the options and their effects on the SDG 6 Targets in a broader context using scientific literature, and discussing implications for the international scientific community. The authors, as SDG 6 working group in UniNETZ, were the main contributors during the

preparation of the options and measures and have been the group carrying out their evaluation. Within UniNetZ, SDG 6 options are also assessed against their effects on the targets of other SDGs. This process is still ongoing and thus not presented in this paper.

The article is structured as follows: After a description of the material and methods, the results and discussion section starts with presenting and discussing each of the eleven options (context, measures and their evaluation), followed by a general discussion of the evaluation method used. Finally, some conclusions and implications for further research are outlined.

2. Material and methods

Following a mapping of expertise on the SDGs in the Austrian research arena (Körffgen et al., 2019), the SDG 6 working group of the UniNetZ project was formed. The core group working on SDG 6 consisted of eight participants corresponding to the authors of this paper. The covered research fields include water and sanitation infrastructure and management, wastewater treatment, groundwater and hydrogeology, nature-based solutions, resource recovery, material sciences, water pollution control, hydrobiology and international development cooperation and were complemented during the course of the project with experts from other fields whenever needed. To propose consistent and structured processes for the development and description of options within the whole project, a manual was prepared in an interdisciplinary group. A key step in this manual is the contextualization of the goals and targets according to a selected method based on which the options are derived and developed (Horvath et al., 2021).

Within the SDG 6 working group problem areas were identified and potential ideas for options were collected based on conceptual system models and several discussions as well as a thorough contextualization of the targets (Germann et al., 2021) and a critical appraisal of the indicators (Germann and Langergraber, 2022). Lead authors for the options were assigned according to their expertise, and additional input was requested where needed. Once a first draft based on the authors' expertise was outlined and complemented using literature, an intensive iterative process to further develop and refine the options started. It involved several discussions within the SDG 6 group and an internal review, followed by discussions of the options with working groups of the other SDGs in the UniNetZ project and with stakeholders, as well as an external review. The descriptions of the developed options include objectives, background, specific measures, expected impacts, previous experiences, and potential interactions with other SDGs and are made available online (Allianz Nachhaltige Universitäten und Österreich, 2021). The numbering of the options was chosen randomly, and no prioritization or ranking should be derived from it.

Following an evaluation of methods to assess SDG entity interactions (Horvath et al., 2022), a mapping method of Nilsson et al. (2016) was adapted to assess effects of the options developed on the SDG targets within the UniNetZ project (Horvath et al., 2021). The method uses a scale as depicted in Table 1.

Details on the evaluation method are described in Horvath et al. (2021). Within the SDG 6 working group, each measure outlined in an option was assessed against all eight SDG 6 Targets. First, each potential effect was evaluated by at least three individuals of the group. Based on the individual evaluation, the effects' evaluation was discussed in online meetings within the SDG 6 working group until a consensus was found among the experts. Some SDG 6 specific criteria and clarifications for the evaluation that were considered necessary to assure consistency were defined (Table 2). Important and potentially controversial discussion points were recorded and are summarized in the results section for each option. Based on the evaluation of the effects of the measures, the effects of the options on the targets were evaluated.

Table 1

Evaluation scheme of the effects of the options/measures on the SDG targets following Nilsson et al. (2016) and adapted for the UniNetZ project (translated by the authors from Horvath et al., 2021).

Interaction	Name	Explanation
+3	Indispensable	The implementation of the option/measure is essential to achieve a target.
+2	Reinforcing	The implementation of the option/measure enhances the achievement of a target significantly.
+1	Enabling	The implementation of the option/measure creates conditions that are conducive to the achievement of a target.
n	Neutral	The implementation of the option/measure has no significant effect on a target.
-1	Constraining	The implementation of the option/measure creates conditions that are detrimental to the achievement of a target.
-2	Counteracting	The implementation of the option/measure clearly impedes the achievement of a target.
-3	Inhibiting	The implementation of the option/measure makes it impossible to achieve the target.

3. Results and discussion

3.1. Option 1: Resources-oriented sanitation (Germann and Regelsberger, 2021a)

Urban water management is facing various challenges such as climate change, urbanization, migration from rural areas, the need for rehabilitation and modernization of the infrastructure (Kleidorfer et al., 2013) and resource scarcity (Kretschmer et al., 2018). Previous approaches in water resources management and infrastructure services have doubtlessly brought about huge progress in public health protection. Yet, particularly when considering global population growth and increasingly limited resources, sustainable solutions require a paradigm shift from a siloed perspective (i.e. drinking water, wastewater, stormwater, resources management) to holistic management, planning and implementation that maximize recovery of water, energy, nutrients and materials (Ma et al., 2015).

In Option 1, the use of resources-oriented sanitation (ROS) systems is illustrated as part of the solution to address these challenges (Germann and Regelsberger, 2021a). ROS systems refer to sanitation systems that "extend the boundaries of conventional sanitation solutions" (Ronteltap and Langergraber, 2018, p. 106) toward more sustainable water and biogeochemical cycles. Beyond the traditional goal of sanitation to hygienically treat wastewater and human excreta their aim is to close water, energy and material cycles as far as possible and to enable targeted treatment of problematic substances. This is achieved through maximizing the elimination of problematic substances at the source as well as smart and where appropriate separate collection and processing of resources for their further marketability and use (Masi et al., 2018), if possible, locally (Edible City Network (EdiCitNet), 2019). Related terms used are *ecological sanitation* (Langergraber and Muellegger, 2005), *new alternative sanitation systems* (Deutsche Vereinigung für Wasserwirtschaft and Abwasser und Abfall, 2014) or *sustainable sanitation* (Sustainable Sanitation Alliance, 2008). Corresponding planning approaches that recognize the recovery of resources as one of the tasks of sanitation are needed (Germann and Regelsberger, 2021a).

Table 3 summarizes the evaluation of the effects of the measures defined for Option 1 "Resources-oriented sanitation" on the SDG 6 Targets. By promoting ROS systems, the measures aim at the improvement of wastewater treatment and reuse (Target 6.3, Target 6.4), and ultimately at the protection of the quality and quantity of water-related ecosystems (Target 6.6). As outlined in measure 1.6 and 1.7, new formats for planning and design and intensifying interaction with stakeholders and the public will be needed to implement the suggested measures and will help to advance Target 6.b. Promoting closed loops in

Table 2

SDG 6 specific clarifications and criteria for the evaluation of the effects of the identified measures on the SDG 6 Targets.

Target	SDG 6 specific clarifications and criteria for the evaluation
General	<p>The effect of an option on a target can be based on only one or a few measures of this option (e.g., if one measure is rated +3, the entire option for this target can be rated +3) if it is particularly relevant and if a corresponding consensus is found in the group.</p> <p>While negative effects are generally possible due to the close coordination in the preparation of the options, no negatively evaluated effects (trade-offs) between SDG 6 Targets and the presented options are to be expected.</p> <p>If there is a strong time lag between the implementation of a measure and the expected impact or effect, the evaluation is down-graded (e.g., training for teachers).</p> <p>In many cases, regionally differentiated consideration is necessary; effects that <i>only</i> have a particularly strong regional impact are still taken into account in the evaluation (e.g., measures to reduce pesticide contamination of water resources in Austria are particularly relevant at the regional level, and are therefore also in the overall evaluation indispensable (+3) for maintaining the drinking water supply or Target 6.1, see, e.g., measure 6.2).</p> <p>If a measure has an indirect effect only (e.g., teaching, research, information campaigns), the evaluation is generally down-graded by at least one level. If the measure is nevertheless consensually considered to be indispensable for achieving a target (e.g., if training programs are considered an essential means of achieving a target), a +3 can still be awarded.</p> <p>In general, only an impact on targets in Austria is assessed. Major spill-over effects are outlined verbally in the text. Some may also be reflected in Target 6.a, provided that SDG 6 relevant impact can be expected. Other than that, if no impact on the targets in Austria was expected, spill-over effects were not taken into account.</p> <p><i>Reinforcing</i> (+2) vs. <i>indispensable</i> (+3): Some measures are indispensable but do not directly/causally reinforce the effect (e.g., improved monitoring if current service works properly). Monitoring measures are generally considered as supporting measures.</p> <p>The current situation in Austria also affects the evaluation e.g. basic knowledge on personal sanitation and hygiene is widely established and is not decisive for further progress on the target. As another example looking at potential +3-evaluations the following question was addressed: Is the measure actually mandatory/indispensable for the achievement of a target in Austria? Essential prerequisites that have already been largely established are not rated +3 (e.g., toilets in houses).</p>
6.1	Generally, the focus of this target is on infrastructure and access to drinking water supply. Still, water quality, particularly of drinking water resources, is an issue. The target goes beyond the household level, comprising e.g., also public spaces. Increasing the efficiency of water use (Target 6.4), recycling and cascades and using locally available water resources according to their suitability (Target 6.3) can also have a positive effect on this target. Yet, if a measure is found to be indispensable (+3) for e.g., 6.3, it could still be evaluated +2 or +1 for 6.1, as it might only have a supporting effect there.
6.2	The target goes beyond the household level, comprising, e.g., also public spaces.
6.3	This target includes not only wastewater treatment but also the reduction of all forms of material and chemical pollution (point and diffuse) to ensure water quality and safe reuse of water and related resources. The reduction of point and diffuse pollution in all types of water bodies (including groundwater) and the contribution to reuse (water and related resources) is covered.
6.4	Poor water quality can also lead to water stress and is considered relevant for Target 6.4, particularly if a potential impact on drinking water resources is expected. For this target, the entire water balance (e.g. also soil, infiltration) is taken into account.
6.5	The evaluation for this target covers also participatory processes as part of integrated water resources management (IWRM). Integrated land use management and impacts of agriculture, forestry, industry and other sectors on water management and resources are important factors as well.
6.6	The evaluation for this target encompasses impacts on the water quality and the ecological and hydro-morphological status of water-related ecosystems.
6.a	As generally the measures have been developed for Austria, impact on 6.a is sparse. If it can be expected, that an inspiring example is set by a measure, the impact of this measure on Target 6.a is rated +1, e.g., legal formulations and guidelines can potentially have an impact beyond Austria's borders as best-practice or state-of-the-art examples.
6.b	Participation implies the active, meaningful contribution of various stakeholders, including individuals and communities, to decisions and foci in the water and sanitation sector (UN Water, 2017). Measures such as information campaigns or training alone are not considered to have a strong impact on this target, but they can <i>create conducive conditions</i> (+1). Education and continuous training on topics that advance SDG 6 are considered to have a positive impact (see Option 2).

water management requires and consequently enhances an integrated perspective and can thereby add to Target 6.5. Not least, promoting novel ROS systems including urine diversion will be crucial to tackle the sanitation challenge in the Global South (Larsen et al., 2021), reduce eutrophication, decrease the rate of an estimated 80% of global wastewater being released untreated into the environment (United Nations World Water Assessment Programme, 2017) and can thereby promote Target 6.a.

3.2. Option 2: Increased use of blue-green-brown infrastructure (Fuchs-Hanusch and Regelsberger, 2021c)

Due to the multiple challenges in urban water management mentioned above, re-establishing a near-natural water cycle by implementing nature-based solutions (NBS) is widely recommended, particularly in vulnerable, urban areas (Oral et al., 2020). Option 2 therefore presents the promotion and establishment of blue-green-brown infrastructure (BGBI) as an alternative to grey infrastructure (concrete sewers and basins, etc.) for rainwater management and decentralized, local treatment and reuse of water such as greywater and wastewater. BGBI comprises plants (green), water surfaces and bodies (blue) and soil (brown) as relevant components of the urban water infrastructure. Integrating the various ecosystem services provided by these elements, BGBI pursues several goals at the same time (Fuchs-Hanusch and Regelsberger, 2021c). These are also reflected by the evaluation of the effects of the measures defined for Option 2 on the SDG 6 Targets (Table 4):

- (1) Improvement of water quality by reducing the discharge of polluted rainwater into water bodies e.g. through measure 2.1 and 2.2 (Target 6.3, 6.6),
- (2) decentralized treatment of greywater or wastewater for local use (Target 6.3),
- (3) reduced water demand for irrigation by increasing reuse and retention capacity (Target 6.4),
- (4) contribution to integrated water resource management at the local level through the use of ecosystem services ("nature-based solutions") and trans-sectoral planning (Target 6.5),
- (5) increase of the proportion of water-related ecosystems through soil protection (Target 6.6),
- (6) contribution to biodiversity through habitat creation, and
- (7) increase of well-being through additional urban green spaces (Gascon et al., 2016; Laaidi et al., 2012; Tzoulas et al., 2007) (SDG 3).

Beyond that, these measures support Target 6.b by educating and promoting BGBI among stakeholders and the public and by strengthening a trans-sectoral perspective. By reducing the discharge into occasionally overloaded conventional sanitation systems in urban areas, safe sanitation and hygiene can be supported. Additionally, the splitting of fees (measure 2.2) was found to potentially lead to a more equitable allocation of sewage costs (Target 6.2). Reduced qualitative and quantitative stress on water resources indirectly contributes to Target 6.1. Good practice examples and exchanging experiences in BGBI can help to tackle challenges in urban water management worldwide (Target 6.a).

Table 3

Evaluation of the effects of the measures defined for Option 1 "Resources-oriented sanitation" (Germann and Regelsberger, 2021a) on the SDG 6 Targets (+3 = indispensable; +2 = reinforcing; +1 = enabling; n = neutral, see Table 1).

#	Measures (for details see supplementary material)	SDG 6 Targets								
		6.1 Drinking water	6.2 Sanitation & hygiene	6.3 WWT* & Reuse	6.4 Water-use efficiency	6.5 IWRM	6.6 Ecosystems	6.a International cooperation	6.b Engagement	
1.1	Provision of financial resources	+1	+2	+3	+2	+2	+2	n	+1	
1.2	Adaptation of regulations and funding guidelines	+1	+1	+3	+2	+2	+2	+1	+1	
1.3	Risk-based targets for reuse	+1	+1	+3	+3	+2	+2	+1	+1	
1.4	Promotion of relevant research	+1	+1	+3	+3	+2	+1	+1	+1	
1.5	Integration into education and continuous training	n	+1	+2	+2	+1	+1	+1	+1	
1.6	Formats for co-design and networking	+1	+1	+2	+2	+2	+2	+1	+3	
1.7	Implementation of pilot projects	+1	+1	+3	+3	+2	+2	+1	+3	
1.8	Application of multi-criteria evaluation methods	+1	+1	+3	+3	+2	+1	+1	+2	
1.9	Establishment of alignment with closed-loops	+1	+1	+3	+3	+2	+1	+1	+1	
1.10	Optimization of (urban) cycles	+1	+1	+3	+2	+2	+2	+1	+1	
1.11	Urban and peri-urban food production	+1	+1	+3	+2	+2	+2	+1	+1	
Option "Resources-oriented sanitation"		+1	+1	+3	+2	+2	+2	+1	+2	

*WWT = waste water treatment

3.3. Option 3: Promoting efficient use and management of water resources (Fuchs-Hanusch et al., 2021)

Option 3 aims at increasing water use efficiency (Target 6.4), reducing water losses in supply systems and identifying possibilities for securing water supply alternatives to expanding the development of natural water resources. These objectives are particularly relevant in the light of climate change, demographic changes, including urbanization and regional population growth, and associated potential impacts on the water balance. Aiming at sustainable, preventive conservation of water resources and consequently taking into account an unfavorable scenario, regionally competing water needs will likely be an issue in Austria (Lindinger et al., 2021) and need to be addressed with foresight. Measures like the promotion of efficient technologies in water management and pertinent awareness raising are already outlined in the Austrian strategy for climate adaptation (Bundesministerium für Nachhaltigkeit und Tourismus (BMNT), 2017, p. 83). Yet, about two-thirds of the Austrian water footprint corresponds to the external water footprint (Neunteufel et al., 2021; Vanham, 2012), adding to the increasing global water stress (Gassert et al., 2013). Thus, apart from measures for efficient water use in Austria, the need for measures to decrease the impact of Austrian consumption patterns on water resources beyond the country's borders is evident.

Table 5 shows the summarized assessment of the effects of the measures defined in Option 3 on the SDG 6 Targets. The main effect is an increase in water-use efficiency (Target 6.4). By protecting drinking water resources and improving the water supply infrastructure, Target 6.1 is enhanced as well. Measure 3.4 replicates measure 2.2 as it is equally relevant for both, Option 2 and 3. Some measures of Option 3 also contribute to the reuse of water (Target 6.3) and enhance integrated planning and cooperation in water management (Target 6.5). Others support engagement and awareness raising on efficient water use in general (Target 6.b) and virtual water and its external impacts (Target 6.a).

3.4. Option 4: Maintain and restore the ecological functions of inland waters (incl. peatlands and wetlands) (Borgwardt et al., 2021a)

Water is indispensable for sustaining life on Earth, and by nurturing freshwater ecosystems and upholding their functions and biodiversity, it is an essential source of resilience in the socio-ecological system (Boltz et al., 2015; Falkenmark et al., 2019). Yet, as put in a nutshell by the Leibniz-Institut für Gewässerökologie und Binnenfischerei (2019), freshwater biodiversity is threatened by a silent and, in a twofold sense, unnoticed crisis: it occurs below the water surface and is often overlooked by the society, economy and politics. Biodiversity in inland waters is declining even faster than on land or in the sea (He et al., 2019; He and Jähmig, 2019; Reid et al., 2019).

Option 4, therefore, presents urgently needed policy recommendations (Harrison et al., 2018) that aim at the protection and restoration of water-related ecosystems (Target 6.6). Besides already identified restoration needs for rivers and streams (i.e. hydro-morphological improvements and reducing fragmentation by barriers), special focus needs to be given to wetlands and peatlands, as so far, measures for their protection and conservation have been insufficient, and many types in Austria are listed as endangered (Traxler et al., 2005). The conservation and restoration of ecological functions of water-related ecosystems and a determined implementation of restoration measures can contribute to the achievement of the SDGs in manifold ways (Jaramillo et al., 2019; Seifollahi-Aghmiuni et al., 2019). In the context of Austria, besides impacts on SDG 6, particularly strong effects on specific targets of SDG 15 are expected (Borgwardt et al., 2021a).

Table 6 depicts the evaluation of the effects of the measures defined in Option 4 on the SDG 6 Targets. As can be seen, the main effect is the protection and restoration of water-related ecosystems, their functions, ecosystem services, and biodiversity (Target 6.6). Another significant contribution is attributed to IWRM (Target 6.5), mainly by giving attention to the interconnections between water bodies and their surrounding ecosystems, thus supporting an integrative perspective. Comprehensive implementation of the European Water Framework Directive (WFD) (measure 4.1) additionally enhances the protection of

Table 4

Evaluation of the effects of the measures defined for Option 2 “Increased use of blue-green-brown infrastructure” (Fuchs-Hanusch and Regelsberger, 2021c) on the SDG 6 Targets (+3 = indispensable; +2 = reinforcing; +1 = enabling; n = neutral).

#	Measures (for details see supplementary material)	SDG 6 Targets							
		6.1 Drinking water	6.2 Sanitation & hygiene	6.3 WWT & Reuse	6.4 Water-use efficiency	6.5 IWRM	6.6 Ecosystems	6.a International cooperation	6.b Engagement
2.1	Legal requirements, subsidies and other measures to promote unsealing	+1	+1	+3	+3	+2	+2	+1	+1
2.2	Splitting of fees for discharging wastewater and stormwater for local stormwater management	+1	+1	+2	+3	+2	+2	n	+1
2.3	Development of assessment basics for the use of BGBI by engineers	+1	+1	+2	+2	+2	+2	+1	+1
2.4	Integrate BGBI approaches into education (curricula of relevant professions)	+1	+1	+2	+2	+2	+2	+1	+2
2.5	Qualification programs for professionals for near-term, increased use of BGBI	+1	+1	+2	+2	+2	+2	+1	+2
2.6	Consideration of the multiple benefits of BGBI in planning and promotion	+1	+1	+3	+3	+2	+2	+1	+2
2.7	Promoting synergies through trans-sectoral planning of urban infrastructure projects	+1	+1	+3	+3	+3	+2	+1	+2
Option	“Increased use of Blue-Green-Brown Infrastructure”	+1	+1	+3	+3	+2	+2	+1	+2

Table 5

Evaluation of the effects of the measures defined for Option 3 “Promoting efficient use and management of water resources” (Fuchs-Hanusch et al., 2021) on the SDG 6 Targets (+3 = indispensable; +2 = reinforcing; +1 = enabling; n = neutral).

#	Measures (for details see supplementary material)	SDG 6 Targets							
		6.1 Drinking water	6.2 Sanitation & hygiene	6.3 WWT & Reuse	6.4 Water-use efficiency	6.5 IWRM	6.6 Ecosystems	6.a International cooperation	6.b Engagement
3.1	Definition of specific quality standards	+2	n	+3	+3	+2	+1	+1	+1
3.2	Networking between companies	+2	n	+3	+3	+2	+1	+1	+2
3.3	Promote and advertise water-saving technologies and farming practices in agriculture	+2	n	+1	+3	+2	+1	+1	+1
3.4	Splitting of fees for discharging wastewater and stormwater	+1	+1	+2	+3	+2	+2	n	+1
3.5	Reduction of peak consumption	+2	n	+1	+3	+2	+1	+1	+1
3.6	Efficient water use in households	+2	n	+1	+3	+1	+1	+1	+1
3.7	Awareness raising about virtual water	+2	n	+1	+3	+2	+1	+2	+2
3.8	Planning of resource use	+2	n	+2	+3	+2	+1	+1	+1
3.9	Water pipeline rehabilitation	+2	n	+1	+3	+1	n	n	+1
3.10	Increased monitoring	+2	n	n	+3	+1	n	n	+1
3.11	Information on own water consumption	+2	n	n	+3	+1	+1	n	+2
3.12	(Condition-based) maintenance and rehabilitation measures	+2	n	n	+3	+1	+1	n	+1
3.13	Research on efficient water use	+2	n	+2	+3	+2	+1	+1	+1
Option	“Promoting efficient use and management of water resources”	+2	n	+2	+3	+2	+1	+1	+1

Table 6

Evaluation of the effects of the measures defined for Option 4 “Maintain and restore the ecological functions of inland waters (incl. peatlands and wetlands)” (Borgwardt et al., 2021a) on the SDG 6 Targets (−3 = indispensable; +2 = reinforcing; +1 = enabling; n = neutral).

#	Measures (for details see supplementary material)	SDG 6 Targets							
		6.1 Drinking water	6.2 Sanitation & hygiene	6.3 WWT & Reuse	6.4 Water-use efficiency	6.5 IWRM	6.6 Ecosystems	6.a International cooperation	6.b Engagement
4.1	Full implementation of the EU Water Framework Directive (WFD)	+2	n	+2	+1	+3	+3	n	+2
4.2	Ban of interventions in water bodies with “very good ecological status”*	n	n	+1	n	+2	+3	n	+1
4.3	Promotion of near-natural flood protection	+1	n	n	+1	+3	+3	n	+1
4.4	Creation of riparian strips with near-natural vegetation	+1	n	+1	+1	+2	+3	n	+1
4.5	Promotion of lateral connectivity between watercourses, floodplains and the surrounding	+1	n	+1	+1	+2	+3	n	+1
4.6	Reduction of soil erosion and of input of fine sediments, nutrients and pesticides	+1	n	+2	+1	+3	+3	n	+1
4.7	Preservation and absolute protection of existing peatlands and wetlands	+1	n	+1	+1	+2	+3	n	+1
4.8	Integrated planning and management of water resources	+1	n	+1	+1	+3	+3	+1	+2
Option	“Maintain and restore the ecological functions of inland waters (incl. peatlands and wetlands)”	+1	n	+1	+1	+2	+3	n	+1

*According to the WFD (European Parliament and Council of the European Union, 2000)

the water quality (Target 6.3, Target 6.1) and participation and stakeholder interaction (Target 6.b). Including increased water retention capacity and the role of sufficient water quality to impede water stress in the evaluation, favorable effects for Target 6.4 are expected as well. Potentially unfavorable consequences for existing drinking water wells and infrastructure due to measure 4.2 were discussed, but the measure was consensually agreed to be overall neutral for Target 6.1.

3.5. Option 5: Reduction of diffuse discharge of nutrients and problematic substances (Fuchs-Hanusch and Regelsberger, 2021b)

Preventing discharges of nutrients and problematic substances from anthropogenic sources to water bodies is essential for maintaining beneficial and protective services and functions of water ecosystems (Häder et al., 2020) and for achieving the goal of a good ecological status of water bodies set in the WFD (Bundesministerium für Landwirtschaft, Regionen und Tourismus (BMLRT), 2021; European Parliament and Council of the European Union, 2000). With diffuse inputs from agriculture as one of the main sources of pollution, reducing these inputs is found to be critical to protect water bodies in Austria (Schilling et al., 2011). Besides increasing pollution of ecosystems, the synthesis of ammonia fertilizer and its excessive use – while having a substantial, multifaceted impact on the course of the last century and the state of the world today – are recognized to have several “unintended consequences”, such as a significant energy consumption (about 1% of the global primary energy supply) and alterations of the greenhouse gas balance (Erismann et al., 2008). At the global level, nitrogen and phosphorus cycles exceed the safe operating space within the planetary boundaries by far (Steffen et al., 2015). Phosphorus is a finite resource, and as its currently economically exploitable natural reserves are restricted to only a few countries, critical dependencies and corresponding geopolitical risk demand for supply diversification as mitigation measure (Egle

et al., 2016; Scholz et al., 2014). But also soil itself, particularly healthy soil, is a finite resource, that needs to be protected from continuous degradation and erosion (Glaser et al., 2010; Laishram et al., 2012). Consequently, the aim of this option is to reduce the loss of nutrients from soils or soil as a whole, as far as possible (Fuchs-Hanusch and Regelsberger, 2021b).

Table 7 summarizes the assessment of the effects of the measures defined in Option 5 on the SDG 6 Targets. The measures are intended to protect water bodies (Target 6.3 in general and Indicator 6.3.2 in particular), promote aquatic ecosystems (Target 6.6), keep finite resources within the cycle, and increase the share of sustainable agriculture (Target 12.2; Target 2.4). This shall be achieved on the one hand through protective measures between agricultural areas and water bodies, and on the other hand through adaptations in agricultural practices, leading to enhanced IWRM (Target 6.5). Ultimately, the measures will also have positive effects on drinking water resources (Target 6.1) and support activities engaging various stakeholders and the public (Target 6.b).

3.6. Option 6: Reduction of trace substances (Fischer et al., 2021)

The objective of the option is to reduce trace substances in water bodies. Trace substances or micro-pollutants are generally understood to be substances that occur in water bodies and have adverse effects on aquatic ecosystems and/or organisms even in very low concentrations (Hillenbrand et al., 2019). Similar, partly overlapping, and sometimes synonymously used terms are *micropollutants* or *microcontaminants* (Hillenbrand et al., 2019; Umweltbundesamt, 2015). In addition to synthetic organic substances (e.g., pesticides, industrial and household chemicals, plasticizers, substances from personal care products or pharmaceutical residues), the term trace substances within Option 6 includes microplastics and fibers as well as nanoparticles and heavy

Table 7

Evaluation of the effects of the measures defined for Option 5 “Reduction of diffuse discharge of nutrients and problematic substances” (Fuchs-Hanusch and Regelsberger, 2021b) on the SDG 6 Targets (+3 = indispensable; +2 = reinforcing; +1 = enabling; n = neutral).

#	Measures (for details see supplementary material)	SDG 6 Targets							
		6.1 Drinking water	6.2 Sanitation & hygiene	6.3 WWT & Reuse	6.4 Water-use efficiency	6.5 IWRM	6.6 Ecosystems	6.a International cooperation	6.b Engagement
5.1	Establishment and protection of buffer zones along water bodies	+1	n	+3	+1	+2	+3	n	+1
5.2	Need-based fertilization and soil-conserving management	+2	n	+3	+1	+2	+3	n	+1
5.3	Targets and supporting measures for the transition to organic farming	+2	n	+2	+1	+2	+3	n	+1
5.4	Promote research on nutrient recovery from drainage effluents	+1	n	+3	n	+2	+2	+1	+1
5.5	Establishment of wetlands and wet meadows through supporting measures	+2	n	+1	+1	+2	+3	n	+1
5.6	Promote decentralized resource-oriented sanitation systems	+1	+1	+3	+2	+2	+2	+1	+2
Option	“Reduction of diffuse discharge of nutrients and problematic substances”	+2	n	+3	+1	+2	+3	n	+1

metals. Often, these trace substances are not or only insufficiently removed within current wastewater treatment and thus enter water bodies, soil, and groundwater. Due to the diversity of substances, sources and input pathways (Hillenbrand et al., 2019), a broad set of different measures is suggested (source-based, application-oriented and downstream/end-of-pipe). Yet, since their removal is mostly difficult and expensive, preventing their use and input in the first place is recommended as the measure of choice wherever possible and effective (Fischer et al., 2021). This is also supported by the European Directive on priority substances in the field of water policy (Council of the European Union and European Parliament, 2013), which defines measures at the source as a priority to prevent environmental pollution.

Table 8 summarizes the assessment of effects of the measures defined in Option 6 on the SDG 6 Targets. Primarily, the measures aim at decreasing the input of trace substances to reduce pollution of water bodies and the presence of hazardous substances in the long term (Target 6.3 and 6.6). Ultimately, they help to ensure the required quality of drinking water resources (Target 6.1) and reduce quality-induced water stress (Target 6.4). As various sectors are affected, an integrated view is paramount (Target 6.5) and engagement and understanding by and among stakeholders is encouraged (Target 6.b).

3.7. Option 7: Drinking water and sanitation in public spaces (Germann and Regelsberger, 2021b)

The aim of this option is to enhance inclusive and equal access to drinking water and sanitation facilities for all, with a focus on public spaces. Particularly through the lens of a human rights perspective, the provision of sanitation has shown to be indispensable for providing safe and inclusive access to public spaces for all (Moreira et al., 2021). While provision of water and sanitation facilities beyond the household level in public spaces is implied in Target 6.1 and 6.2 by demanding *universal, for all* and *equitable* access, it is not or insufficiently covered by the SDG indicators (Guppy et al., 2019; United Nations General Assembly, 2019) and consequently potentially overlooked in SDG-related decision-making. Several other normative aspects are, while emphasized in the two

targets, not or only insufficiently addressed by the monitoring framework (Germann and Langergraber, 2022). These include *affordability of safe drinking water* and *adequate and equitable sanitation and hygiene for all [...] paying special attention to the needs of women and girls and those in vulnerable situations* (United Nations, 2015). Vulnerable and marginalized groups include, e.g., people with health impairments (such as incontinence or Crohn’s disease) or disabilities, elderly, women, children, transgender people, people with prams, people working outdoors, homeless people, and other ethnic and social minorities. Recognizing the Agenda’s pledge to *Leave no one behind* (LNOB) (Renner et al., 2018; United Nations Sustainable Development Group, 2022), the measures of Option 7 are derived from these aspects and amended where needed.

Table 9 displays the assessment of the effects of the measures defined in Option 7 on the SDG 6 Targets. Positive effects on Target 6.1 and 6.2 are expected by addressing the aspects described above, particularly equitable access (Greed, 2016; Hale, 2019; World Health Organization, 2007). Besides that, the outlined measures will contribute to and be dependent on the cooperation with municipalities and local communities (Target 6.b). More frequent provision of sanitation facilities can reduce local and temporal degradation of water quality and public nuisance (olfactory and visual) caused by repeated indiscriminate urination or defecation (Target 6.3). The provision of drinking fountains in public spaces can promote a preference for drinking tap water compared to bottled water or soft drinks. Several studies show that tap water should be favored over bottled water in terms of energy input (Gleick and Cooley, 2009), overall environmental impact (Nicolics et al., 2014; Villanueva et al., 2021) and - if water losses in the pipelines are kept low - considering the total water use (Target 6.4) (Niccolucci et al., 2011). Additionally, public water fountains support adaptation to climate change (Magistratsabteilung 22, 2015; Prutsch et al., 2014) and, by promoting the maintenance of a good hydration status (Manz, 2007) and the consumption of water instead of sugary drinks, they can lead to several positive health effects (Daniels and Popkin, 2010; Muckelbauer et al., 2016). Experiences and learnings from Option 7 could help to draw some general implications for water and sanitation facilities in public spaces, a topic often neglected but highly relevant also in

Table 8

Evaluation of the effects of the measures defined for Option 6 “Reduction of trace substances” (Fischer et al., 2021) on the SDG 6 Targets (+3 = indispensable; +2 = reinforcing; +1 = enabling; n = neutral).

#	Measures (for details see supplementary material)	SDG 6 Targets							
		6.1 Drinking water	6.2 Sanitation & hygiene	6.3 WWT & Reuse	6.4 Water-use efficiency	6.5 IWRM	6.6 Ecosystems	6.a International cooperation	6.b Engagement
6.1.	Increasing the understanding among consumers and producers	+2	n	+2	+1	+2	+2	+1	+3
6.2.	National strategy on pesticides and antibiotics	+2	n	+3	+1	+2	+3	n	+1
6.3.	Reduction of pharmaceutical substances in agriculture	+1	n	+3	+2	+3	+3	n	+1
6.4.	Reduction of pesticides in agriculture and thus of their input into water bodies	+2	n	+3	+2	+3	+3	n	+1
6.5.	Reduce and avoid harmful chemicals in industrial production	+1	n	+3	+1	+2	+3	+1	n
6.6.	Reduction and avoidance of harmful chemicals in building materials	+1	n	+3	+1	+2	+3	n	+1
6.7.	Measures to reduce the input of microplastics into water bodies	+1	n	+3	+1	+2	+3	n	+1
6.8.	Polluter-Pays-Principle to increase fairness of charges	+2	n	+2	+2	+2	+2	+1	+2
Option	“Reduction of trace substances”	+2	n	+3	+1	+2	+3	n	+1

countries of the Global South (Target 6.a) (Joshi, 2018; Paul et al., 2020).

3.8. Option 8: Improved groundwater protection through research based on demand (Schubert et al., 2021)

Groundwater is an essential resource for drinking water supply,

irrigation, livestock, industry and hydropower and is an indispensable component of many aquatic and terrestrial ecosystems (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), 2017; Lindinger et al., 2021). It is used for natural mineral water, medicinal springs and thermal baths, as well as for geothermal use. Yet, the diverse anthropogenic uses pose a potential risk to the quantity and quality of groundwater resources, which is exacerbated by

Table 9

Evaluation of the effects of the measures defined for Option 7 “Drinking water and sanitation in public spaces” (Germann and Regelsberger, 2021b) on the SDG 6 Targets (+3 = indispensable; +2 = reinforcing; +1 = enabling; n = neutral).

#	Measures (for details see supplementary material)	SDG 6 Targets							
		6.1 Drinking water	6.2 Sanitation & hygiene	6.3 WWT & Reuse	6.4 Water-use efficiency	6.5 IWRM	6.6 Ecosystems	6.a International cooperation	6.b Engagement
7.1.	Barrier-free access	+3	+3	n	n	n	n	+1	+2
7.2.	Economic efficiency	+2	+2	+1	n	n	n	+1	+2
7.3.	Decoupling consumption / fees	+3	+2	+1	+1	n	+1	+1	+1
7.4.	Findability / availability / accessibility	+3	+3	+1	n	n	n	n	+1
7.5.	Maintenance & cleaning	+1	+2	n	n	n	n	+1	n
7.6.	Hygienic conditions	+3	+3	n	n	n	n	+1	+2
7.7.	Ecological standards, innovation	+1	+1	+2	+1	n	+1	+1	+2
7.8.	Gender equality	+1	+3	n	n	n	n	+1	+2
7.9.	Safety of toilet facilities	n	+3	n	n	n	n	+1	+2
Option	“Drinking water and sanitation in public spaces”	+3	+3	+1	+1	n	n	+1	+2

Table 10

Evaluation of the effects of the measures defined for Option 8 “Improved groundwater protection through research based on demand” (Schubert et al., 2021) on the SDG 6 Targets (−3 = indispensable; +2 = reinforcing; +1 = enabling; n = neutral)

#	Measures (for details see supplementary material)	SDG 6 Targets							
		6.1 Drinking water	6.2 Sanitation & hygiene	6.3 WWT & Reuse	6.4 Water-use efficiency	6.5 IWRM	6.6 Ecosystems	6.a International cooperation	6.b Engagement
8.1.	Studies on anticipatory groundwater protection in respect to climate change	+2	n	+2	+3	+2	+3	+1	n
8.2.	Extension of soil water and seepage water monitoring	+2	n	+2	+1	+2	+2	+1	n
8.3.	Research on intrinsic vulnerability of karst, fissure and pore aquifers	+2	n	+2	+2	+2	+2	+1	n
8.4.	Source identification of diffuse pollutants	+2	n	+2	+2	+2	+2	+1	n
8.5.	Research on the topic of bank filtrate and river renaturation	+2	n	+2	+2	+2	+2	+1	n
8.6.	Exploration of thermal water resources with regard to groundwater protection & sustainable geothermal use	+1	n	+2	+1	+2	+2	+1	n
8.7.	Regional studies on the sustainable use of deep groundwater for emergency drinking water supply	+3	n	+1	+2	+2	+2	+1	n
Option	“Improved groundwater protection through research based on demand”	+2	n	+2	+2	+2	+2	+1	n*

* While the effects of the measures and option on Target 6.b were found to be neutral, stakeholder engagement is often a necessary prerequisite for the implementation of the measures, and particularly their orientation based on demand.

the effects of climate change. According to current studies in Austria, an increase in heavy rains, intensification of flood risk, a decrease in groundwater recharge, particularly in regions with low precipitation in Southern and Eastern Austria, and longer dry periods in the Alps are to be expected (Blöschl et al., 2017). The option points out the most necessary groundwater-related research topics to improve the protection and sustainable use of Austria’s groundwater.

Table 10 summarizes the assessment of the effects of the measures defined in Option 8 on the SDG 6 Targets. The option describes measures for demand-oriented research to improve the knowledge on anticipatory protection (Target 6.6), improvement of ambient water quality (6.3), as well as sustainable use and management of groundwater resources (Target 6.4). As groundwater (from springs and wells) is the only water resource used for drinking water supply in Austria (Lindinger et al., 2021), the measures contribute thereby also significantly to Target 6.1. Measure 8.7 will be particularly important for securing drinking water supply in potential emergency situations. By enhancing the understanding of the nature and properties of the groundwater cover and aquifers, flow and transport processes taking place in the seepage zone and in the groundwater, substance behavior, and the interaction between surface water and groundwater, research can contribute significantly to solving the existing challenges and balancing potential intersectoral trade-offs (Target 6.5). Although the studies proposed have a regional focus, the research can contribute to a better understanding of groundwater and corresponding processes in general and can serve as an example for regional scale studies worldwide (Target 6.a). For the implementation of the measures, and particularly their orientation based on demand, stakeholder engagement is a necessary precondition. Yet, as it was generally the effects and not potential prerequisites that were evaluated, the measures’ and the option’s evaluation for Target 6.b

was agreed to be neutral.

3.9. Option 9: Strengthening Integrated Water Resources Management for sustainable use of water resources (Borgwardt et al., 2021b)

As described before, there exists a multitude of anthropogenic, potentially competing water demands including for drinking, for irrigation and cultivation of agricultural fields, for manufacturing goods, or for generating electricity in power plants. All these uses and demands can stress resources and water-related ecosystems, not only quantitatively but also qualitatively, through contamination with a variety of substances that often cause challenges in terms of sustainable management. To establish the necessary integrated, encompassing perspective, often Integrated Water Resources Management (IWRM) is suggested (Biswas, 2004; Grigg, 2008; Pahl-Wostl, 2017; Rahaman and Varis, 2005). IWRM is, according to the definition of Agarwal et al. (2000, p. 22), „a process which promotes the co-ordinated development and management of water, land and related resources, to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems”.

Table 11 summarizes the assessment of the effects of the measures defined in Option 9 on the Targets of SDG 6. The primary objective of Option 9 is to enhance and implement IWRM at all levels by 2030, including through transboundary cooperation where appropriate (Target 6.5). As a water management concept, IWRM aims to enable the establishment of a holistic approach for the sustainable management of water resources and an optimal balance of interests between competing sectors (e.g., water, energy and agriculture), with co-creation as a central element (Target 6.b). Strengthened cooperation (measure 9.3), e.g., along the water-food-energy nexus, can help to protect water resources

Table 11

Evaluation of the effects of the measures defined for Option 9 “Strengthening Integrated Water Resources Management for sustainable use of water resources” (Borgwardt et al., 2021b) on the SDG 6 Targets (+3 = indispensable; +2 = reinforcing; +1 = enabling; n = neutral).

#	Measures (for details see supplementary material)	SDG 6 Targets							
		6.1 Drinking water	6.2 Sanitation & hygiene	6.3 WWT & Reuse	6.4 Water-use efficiency	6.5 IWRM	6.6 Ecosystems	6.a International cooperation	6.b Engagement
9.1.	Recording and monitoring human interventions and uses	+2	n	+2	+2	+2	+2	+1	+1
9.2.	Consideration of ecological indicators and water-specific criteria	+2	n	+2	+2	+3	+3	+1	+1
9.3.	Strengthening inter- and trans-sectoral as well as trans-regional cooperation	+2	n	+3	+2	+3	+2	+1	+3
9.4.	New strategies for assessment and communication	+1	n	+1	+1	+3	+2	+1	+3
9.5.	Minimizing climate-related water risks (e.g. due to heavy rainfall, drought, etc.)	+2	n	+2	+3	+3	+2	+1	+1
9.6.	Financing a sustainable transformation of the water sector and other water uses	+2	n	+2	+2	+3	+3	+1	+2
9.7.	Natural water retention measures (NWRM) and no-regret measures	+2	n	+2	+2	+3	+3	+1	+1
Option	“Strengthening IWRM for sustainable use of water resources”	+2	n	+2	+2	+3	+3	+1	+2

(Target 6.3) and water-related ecosystems (Target 6.6) from e.g., diffuse pollution. The allocation of sufficient financial resources for that is particularly important (measure 9.6). Exemplary application and strengthening of IWRM could support and improve its implementation worldwide (6.a).

3.10. Option 10: Increasing WASH-relevant development cooperation (Langergraber, 2021)

Option 10 aims at Target 6.a on expanding international cooperation and capacity-building (UN Water, 2017). The corresponding Indicator 6.a.1 “Amount of water- and sanitation-related official development assistance that is part of a government coordinated spending plan” (UN Water, 2017, p. 22) is – besides several other shortcomings – found not to be entirely consistent with the Agenda’s claim of universal applicability (Bartram et al., 2018) meaning to be applicable to “developed and developing countries alike” (United Nations, 2015). For Austria, being a donor country, this indicator is not applicable (UN Water, 2022). As an alternative, the WASH-relevant (WASH = Water, Sanitation & Hygiene) amount or share of development cooperation for countries in the Global South by Austria could be monitored. Addressing WASH in general and not water alone is important firstly because of its direct link to Target 6.a and secondly because most WASH-relevant development cooperation still focuses on drinking water supply often neglecting sanitation and hygiene. Throughout the option, it is necessary to explicitly take into account so-called cross-cutting issues of environment, gender and social inclusion, a common practice in development cooperation, and especially in WASH projects (Langergraber, 2021).

Table 12 summarizes the effects of the measures identified in Option 10 on the SDG 6 Targets. By strengthening Austria’s WASH-relevant development cooperation and thus increasing Target 6.a, this option

seeks a direct impact in the recipient countries rather than affecting other SDG 6 Targets in Austria.

3.11. Option 11: Promoting transformation processes through co-design and co-creation (Fuchs-Hanusch and Regelsberger, 2021a)

The aim of Option 11 is to achieve all targets of SDG 6 by mobilizing the existing “wisdom of crowds” (Surowiecki, 2004). Rather than having a small group of decision-makers and planners designing, prescribing and implementing the required transformations, the development of solutions should already be undertaken collaboratively by a diverse and broad group of stakeholders (also referred to as co-design or co-creation). In fact, Surowiecki (2004) finds experts and (opinion) leaders to be a rather obsolete model for solving the challenges the society of the future is facing. This option is consequently essential to successfully initiate and implement the transformation defined in all the other options presented in this paper. Indeed, transdisciplinary and participatory research and decision-making are found to be essential for transformational processes throughout the Agenda 2030 and related sustainability challenges (Berry et al., 2019; Lang et al., 2012). Target 16.7, for example, specifically aims to “ensure responsive, inclusive, participatory and representative decision-making at all levels” (United Nations, 2015). For universities, the SDGs pose an exceptional opportunity to engage with external stakeholders (Leal Filho et al., 2019).

Table 13 summarizes the assessment of the effects of the measures defined in Option 11 on the SDG 6 targets. Many of the measures are found to be indispensable to achieve Target 6.b, but also Target 6.5 on IWRM, for which – with participation as one of its main categories - co-creation is found to be fundamental. Measure 11.5 is important to ensure that co-creation and co-design processes are actually applied in practice and therefore identified to have particularly strong direct effects on the

Table 12

Evaluation of the effects of the measures defined for Option 10 “Increasing WASH-relevant development cooperation” on the SDG 6 Targets (Langergraber, 2021) (+3 = indispensable; +2 = reinforcing; +1 = enabling; n = neutral).

#	Measures (for details see supplementary material)	SDG 6 Targets							
		6.1 Drinking water	6.2 Sanitation & hygiene	6.3 WWT & Reuse	6.4 Water-use efficiency	6.5 IWRM	6.6 Ecosystems	6.a International cooperation	6.b Engagement
10.1.	Increase Official Development Assistance (ODA)	n	n	n	n	n	n	+3	n
10.2.	Development of coherent WASH development cooperation	n	n	n	n	n	n	+3	n
10.3.	Expansion of thematic project and funding frameworks for WASH-relevant topics.	n	n	n	n	n	n	+3	n
Option	“Increasing WASH-relevant development cooperation”	n	n	n	n	n	n	+3	n

achievement of the targets. Enhancing collaborative processes will allow harnessing reuse and recycling potentials (Target 6.3 and 6.4). Yet, for systemic transformation, corresponding co-creative processes cannot look at these targets in isolation but need to include the user interface and, consequently, Target 6.1 and 6.2. Concerning Target 6.6, this option is particularly important to support consensus-building in the often sensitive and lengthy debate about necessary area requirements for renaturation, thereby improving the processes. While participatory and co-creative methods have a long history in international cooperation and development practice (Claridge, 2004; Glenn, 2009; Pretty, 1995), enhancing capacity building and further experiences with co-creation practice can contribute to relevant knowledge gain for participatory practices worldwide (Target 6.a). In total, Option 11 is evaluated to have the highest effects on the SDG 6 Targets amongst all the options presented.

3.12. Summary and discussion of the evaluation

Eleven options with a total of 85 measures were identified and evaluated against each of the eight SDG 6 Targets. While comprehensiveness must not be claimed, the results present a diverse set of options and measures that can advance all SDG 6 Targets in different ways. Table 14 displays the number of types of evaluation (+3, +2, +1, n) given to each target. As can be seen, the number of measures found to be *indivisible* is highest for Target 6.3, 6.4, and 6.6. This indicates the high relevance of these targets for the context of Austria, which has also been identified by Germann and Langergraber (2022). It shows that while there are certain deficits in the implementation of these targets, potential remedies to boost them are available. The relatively low evaluations of the measures concerning Target 6.1 and 6.2 could be linked to them being generally widely achieved in Austria. The proposed measures that are found to be *indivisible* to achieve these two targets mainly address specific aspects of the targets, such as e.g., those outlined in Option 7.

Table 13

Evaluation of the effects of the measures defined for Option 11 “Promoting transformation processes through co-design and co-creation” (Fuchs-Hanusch and Regelsberger, 2021a) on the SDG 6 Targets (+3 = indispensable; +2 = reinforcing; +1 = enabling; n = neutral).

#	Measures (for details see supplementary material)	SDG 6 Targets							
		6.1 Drinking water	6.2 Sanitation & hygiene	6.3 WWT & Reuse	6.4 Water-use efficiency	6.5 IWRM	6.6 Ecosystems	6.a International cooperation	6.b Engagement
11.1.	Compilation of a register of experienced facilitators	+1	+1	+2	+1	+2	+2	+1	+3
11.2.	Establishment of training programs for facilitators on co-design/co-creation	+1	+1	+2	+1	+2	+2	+1	+3
11.3.	Inclusion of collaborative processes in education and training	+1	+1	+2	+2	+2	+2	+1	+2
11.4.	Increased use of collaborative processes as a pedagogical concept	+1	+1	+2	+1	+1	+1	+1	+2
11.5.	Co-design/co-creation processes as a prerequisite for subsidies	+2	+2	+3	+3	+3	+3	+1	+3
11.6.	Creating framework conditions for co-creation in municipalities	+1	+1	+3	+3	+3	+2	+1	+3
Option	“Promoting transformation processes through co-design and co-creation”	+1	+2	+3	+2	+3	+2	+1	+3

The means of implementation (MoI) targets, Target 6.a and 6.b, are found to be enabled by a high number of measures, yet few measures are found to directly enhance (+2 or +3) these two targets. This implies a rather low-level systemic impact of the proposed set of options on Targets 6.a and 6.b and underlines the need for more targeted support in the form of specific options (e.g. Option 10 and 11) to achieve these targets.

The options presented here and their evaluation can serve as a scientific baseline for a follow-up implementation process of SDG 6 in Austria. While the results neither should be seen as an exhaustive set of options nor do allow prioritizing or ranking of the options, they aim to give an impetus and describe policy options. Yet, to be implemented, they need further stakeholder discussions and potential adaptations and amendments. Arguably, for decision-makers prioritization might be desirable to define a practicable starting point, and some suggest it to be a necessity to bring forward effective implementation (Bandari et al., 2022; Herrera, 2019; Huan et al., 2022; Weitz et al., 2018). Yet, this would require more detailed analysis of effects on other SDGs, target-to-target interactions (Weitz et al., 2018) as well as the weighting of targets, problem areas, straight-forward or long-term measures etc. Regardless of whether the weighting is equal or not – ultimately, it will be a political decision that demands a thorough debate among stakeholders and is, at least to some extent, biased by the subjective opinion of the participants. Still, a scientific baseline on the effects of measures such as those presented here can guide a consecutive prioritization process.

By proposing a diverse set of options and measures and evaluating the effects on all eight targets, understanding and conveyance of the required systemic perspective within SDG 6 shall be enhanced. The presented assessment illustrates policy options that allow several targets to be addressed simultaneously. As one of the major advancements compared to the corresponding MDG Target 7.C on water and sanitation, SDG 6 covers the whole hydrological cycle, emphasizing “the integrated nature of water and sanitation and its link to sustainability” (Herrera, 2019, p. 109) as well as relevant means of implementation. This circumstance should also be reflected in the corresponding policy-making, and the presented options are an attempt to illustrate how this could be done.

Following a thorough assessment of methods to analyze SDG entity interactions (Horvath et al., 2022), an expert judgment-based approach, a common approach in the literature (Allen et al., 2019; Gjorgievski et al., 2022), was selected due to various qualities. Particularly allowing the consideration of expert knowledge and different types of information (qualitative, quantitative, and implicit) as well as its ability to be used in a collaborative setting and big groups were relevant criteria. It was favored over other argumentative approaches, mainly due to its practicability (transparency, the production of easily interpretable results, no requirement for specialized knowledge of the methodology or computer-based support) and relatively low time effort. Yet, one limitation is that the method does not allow information about the certainty

of the results (Horvath et al., 2022). Further, the results depict effects of the options and measures on the SDG 6 targets but do not assess interactions within the options or targets. Several other assessments suggest that multiple synergies within SDG 6 as well as of SDG 6 with other SDGs exist (Alcamo, 2019; Fader et al., 2018; Jaramillo et al., 2019; Pradhan et al., 2017; Sustainable Sanitation Alliance, 2017a, Sustainable Sanitation Alliance, 2017b; UN Water, 2016). Yet, as many of them are context-specific and depend on how the SDGs are implemented at the local level (Fuso Nerini et al., 2019; Nilsson et al., 2016), evaluation of measures for action in a specific context (such as Austria in this case) are assumed to harvest more reliable and practical results. In the presented evaluation, only effects on the targets of Goal 6 were assessed as these are within the authors’ expertise.

Rather than looking at the overall interactions of the options, evaluating each measure allowed a deepened analysis of the interactions. While the evaluation of the options as a whole can give a good overview, a more detailed evaluation at the level of measures encourages a more sophisticated debate and can lead to a more elaborated basis and reasoning for a potential follow-up discussion process. The options are designed to be implemented as a joint set of measures rather than cherry-picking some. Nevertheless, highlighting the importance of individual measures for a specific target can help underline the need for a joint implementation of the measures to unravel their full potential and deepen understanding of their interdependency. Looking at Option 6, for example, measure 6.1 *Increasing the understanding among consumers and producers* is important to increase the engagement of all stakeholders (Target 6.b), which in the end, will be a prerequisite to actually enabling the implementation of the other measures proposed in this option. As another example, the evaluation of Option 7 illustrates that for exploiting its potential to contribute to Target 6.3 measure 7.7 *Ecological standards, innovation* is particularly important.

By basing the final evaluation on a group consensus, the evaluating group is urged to discuss thoroughly and critically reflect on reasons for potential outliers in the individual evaluations. The final evaluation can, if agreed upon, be adapted correspondingly. This helps to consider all perspectives present and prevents an unintended averaged final evaluation when in fact, the individual evaluation might show opposing opinions. Besides the quantitative assessment, descriptive notes of the reasoning behind the final evaluation were recorded to support understanding, justification and potential follow-up discussion. The notes also served as valuable input for the description of the evaluation of the options in this paper and were incorporated in the corresponding chapters (3.1–3.11).

The evaluation process was conducted within a group of experts who, after several discussions in the project, already shared some common understanding of the SDG 6 Targets. Yet, provided that a minimum level of knowledge on the SDG 6 Targets and a limited group size allowing a constructive and inclusive discussion are given, the

Table 14
Number of types of evaluation (+3, +2, +1, n; see Table 1 for further details) given to the SDG 6 Targets.

Measures evaluation	SDG 6 Targets							
	6.1 Drinking water	6.2 Sanitation & hygiene	6.3 WWT & Reuse	6.4 Water-use efficiency	6.5 IWRM	6.6 Ecosystems	6.a International cooperation	6.b Engagement
+3 (indispensable)	5	5	27	26	15	23	3	9
+2 (reinforcing)	33	5	30	23	51	33	1	21
+1 (enabling)	41	25	16	24	7	17	57	43
n (neutral)	6	51	12	12	12	12	25	12

methods would generally be suitable to include additional stakeholders in the discussion. Some of the measures and their evaluation presented are context-dependent, yet, both can support and inform the development of localized options and measures in similar contexts.

Some subjectivity lies in the development of options (selections of topics as well as a more detailed elaboration of the options) and the evaluation of their effects. For the development of options, this was minimized through elaborated discussions within the SDG 6 expert group as well as debates with and reviews by external stakeholders. For the actual implementation of the measures enhanced exchange with stakeholders and policy-makers is needed. Impacts of subjectivity in the evaluation of the effects were reduced by setting clear general as well as SDG 6 specific criteria for the evaluation, discussions based on at least three independent, individual evaluations and the following need to reach consensus on the overall evaluation (rather than setting the evaluation to a mean value). While evidentially also experts are sensitive to personal values and biases, cross-checks of reasoning and data, discussions prior to (final) judgements as well as a well-structured process can improve the results and their reliability substantially (Burgman et al., 2011).

4. Conclusions

In this paper, we follow a manual developed within the UniNETZ project to identify and evaluate options for implementing the SDGs (Horvath et al., 2021) and demonstrate its application and results at the example of SDG 6. In total, eleven options with 85 measures to advance the SDG 6 Targets in Austria were identified and evaluated in detail. By presenting a broad set of options and measures for action, the paper illustrates challenges that still need to be addressed to comprehensively achieve SDG 6 in Austria, a country with a generally established water and sanitation infrastructure and governance as well as relatively high water availability. The proposed options include resources-oriented sanitation, blue-green-brown infrastructure, efficient use and management of water resources, maintenance and restoration of ecological functions of inland waters, reduction of diffuse discharge of nutrients and problematic substances as well as trace substances, WASH in public spaces, groundwater protection, IWRM, international cooperation as well as co-design and co-creation. The evaluation of the effects illustrates multiple ways in which the presented measures can contribute to achieving the SDG 6 Targets.

The overall approach was found to be useful in developing a broad set of options and measures that addresses all of the SDG 6 Targets, fostering discussion amongst the participating experts and increasing the consideration of the entire hydrological cycle promoted by the goal. The results aim to support and propose a baseline for well-informed follow-up discussions with stakeholders but neither present an exhaustive set of options nor a final prioritization. Provided that a certain level of knowledge on the targets and the corresponding local context is given, the applied approach can be reproduced in other countries or regions to identify and assess effects of measures for action on SDG Targets.

While strong synergies were identified for the targets assessed and SDG 6 is generally found to have particularly frequent synergetic interactions with other SDGs, the probability for trade-offs might be higher when assessing the effects of the presented options on targets of other SDGs (e.g. SDG 7 on affordable and clean energy). Yet, a comprehensive assessment of effects on and interactions with targets of the other SDGs was not in the authors' expertise. Expansion of the evaluation of effects on other SDG Targets would highly contribute to coherent implementation. Follow-up research could further aim at discussing the options within a comprehensive transdisciplinary stakeholder discourse to debate and advance the implementation of the options in more detail. Balancing complexity (e.g. SDG target interactions, local contexts) with the urgent need for practicability for

local decision-making while enabling transdisciplinary processes will be a key to success. A user-friendly, interactive tool that displays the evaluation, reasoning and feedback could support this process.

Credit author statement

Verena Germann: Conceptualization, Methodology, Investigation, Data Curation, Writing - Original Draft, Visualization; Florian Borgwardt, Jörg Fischer, Daniela Fuchs-Hanusch, Martin Regelsberger, Gerhard Schubert & Annett Uhmann: Investigation, Data Curation, Writing - Review & Editing; Günter Langergraber: Conceptualization, Methodology, Supervision, Writing - Review & Editing, Investigation, Data Curation;

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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Appendix A. Supplementary data

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