Chapter

How to Use Scientific Information: Road Map for Tailoring Your Own Natural Hazard Risk Management Solution

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Abstract

In this chapter, we explain how scientific information can effectively be used in the daily work of practitioners. We lead through the process of tailoring research results and scientific information to support an integrated and ecosystem-based natural hazard risk management in the form of a Road Map. This Road Map is based on the RIU (Research Integration Utilization) model for knowledge transfer and backed-up with our long-standing research experience. To illustrate the Road Map, which can be applied to any case of transferring scientific knowledge into practice, we summarize the main results of the GreenRisk4ALPs (GR4A) research project, and propose three steps for integrating them into applied projects or other activities: (1) "Diagnosis" - estimating the relevance of scientific information for applied risk or forest management, (2) "Consultation" - estimating the soundness of the scientific information through consultations with researchers, and (3) "Implementation" – checking the legal framework and the economic resources for the preferred solution. Furthermore, we provide a checklist for stakeholders for tailoring science-based solutions to their practical use, which contributes to facilitating the implementation of research results and can guide policy and practice. Finally, the theoretical and methodological background of the Road Map are presented and discussed.

Keywords: knowledge transfer, RIU model, integrated risk management, checklist for stakeholders, Ecosystem Services-oriented forest use

1. Introduction

Managing natural hazard risks is highly relevant to everyone visiting or living in the Alpine Region (see chapter [1] of this book). Professional risk management is a tool that has been keeping people in the Alpine Region safe for more than 100 years where forests play a key role as risk prevention measure (see chapters [2, 3]) of this book). However, natural hazards such as rockfall, landslides and snow avalanches are still causing severe damages every year [1]. Hence, there is an urgent need to continuously improve Alpine risk management strategies to ensure people's safety in the future [4].

This chapter informs stakeholders how to utilize scientific information from the Interreg Alpine Space project GreenRisk4ALPs (ASP635) [5], and how to form innovative alliances with researchers, which support the selection of science- and ecosystem-based risk mitigation measures. The main stakeholder groups are (i) public agencies involved in risk management, which often have to choose between green, technical and/or avoidance measures such as the reduction of land use in high risk areas; (ii) political actors like mayors, local parliaments or city councils and village boards, which are strongly involved in risk-related issues, and (iii) service providers, service users and citizens of the Alpine Region, for whom natural hazard risk management is highly relevant for their safety. For all these stakeholders it is usually a challenging task to be aware of the most current scientific studies or receive their results, to select the best-fitting ones and to integrate them into science-based solutions that will work in practice. Therefore, in this subchapter we demonstrate how to deal with scientific results and engage scientists after receiving first information about a research project that addresses questions which are important for your own work.

The first contact with a research project may be in any phase of the research process, e.g., in the initial phase, when a research project is being designed and formulated. Or in the end, when project results are finalized, and stakeholders are able to judge their relevance while selecting scientific information that is useful to their interest-oriented action and that can help to improve their own risk management solutions. This Road Map subchapter exemplifies the optimal use of scientific information produced during the GreenRisk4ALPs (GR4A) project. Yet, the way of "making sense of science" is applicable to all other project phases or other scientific projects aiming to facilitate the implementation of scientific information into practice.

1.1 Key results from the GreenRisk4ALPs project

The GR4A project aimed to provide scientific information supporting an ecosystem-based integrated risk management of natural hazards in the Alpine Space, and the acknowledgment of the key role forests have as an Ecosystem-based solution for Disaster Risk Reduction (Eco-DRR) in mountain areas (for risk and other definitions see chapters [1, 2] of this book). Within the project, an international collaboration of researchers and practitioners from 12 institutions developed various products for decision support (e.g., see chapters [6–8] of this book) by applying scientific principles, methods and standards. Many of the scientifically sound GR4A results are listed in a "Catalogue of selected GreenRisk4ALPs research products" (**Table 1**), consisting of a main product (a set of expected and aimed scientific information of a research project) and a by-product (scientific information which supported the development of the main product, but was not the aim of the project or necessarily mentioned in the documented research). The listed products were developed between 2018 and 2021, when researchers were identifying forests with protective functions and quantifying their protective effects against landslides, rockfall and snow avalanches in six GR4A Pilot Action Regions (PARs): Val Ferret, (Italy), Kranjska Gora (Slovenia), Oberammergau (Germany), Baronnies Provençales Regional Nature Park (France), Wipptal South (Italy), and Gries am Brenner and Vals (Austria) (see [9] for descriptions). These analyses and model developments were combined with investigating risk management measures that are currently being applied in the six PARs, as a starting point for considering improvements of existing or introduction of alternative risk management solutions. If you are already active or want to become active in ecosystem-based risk management of natural hazards in the Alpine Region, then the GR4A research products may support your

Research products	Main product	By-product	Ref.
Forest protective function modeling with Flow-Py: open-source regional-scale gravitational natural hazard runout and intensity simulation tool	✓		[6, 10, 11]
Protective forest definition matrix consistent definitions of protective forests to achieve the objectives of GreenRisk4ALPs		✓	[12, 13]
"The forest extension"* for Flow-Py estimates the (protective) effect a forest has on the hazard process (energy reduction = reduction of velocity and runout lengths), dependent on the "actual" forest structure		✓	[6]
"The back-tracking extension"* for Flow-Py identifies the hazard process paths (starting, transit and runout zones) associated with endangering infrastructure		✓	[6, 11]
Maps of "Direct Object Protective Forest forests that are located between natural hazard starting zones and endangered infrastructure	✓		[7]
Maps of "Efficient Green Mitigation Areas" mapping of areas that are highly effective for hazard energy reduction by suggesting: (i) potential areas for afforestation for "Direct object protective forest", (ii) existing "Direct object protective forest" that is highly effective	✓		[7]
Maps of "Impact Reduction Index" show differences in the process intensity from Flow-Py simulations with and without considering the protective effect of "Direct object protective forest"		✓	[7]
GIS-based spatial modelling (spatially explicit assessments): identifying areas where the forest plays a key role in protecting infrastructure from natural hazards; provides regional-scale maps	✓		[7, 14, 15]
Exposure assessment (i) identifies those areas where hazard exposure is reduced due to the presence of forest, (ii) ranks the forest effect by assessing the impact of each hazard type on different types of assets with and without forest effect	✓		[7, 14, 15]
Spatial analysis to identify hotspot areas produces annotated hotspot maps, datasets, a process description, and documentation of results	✓		[7, 14, 15]
Protective Forest Assessment Tool (FAT): online decision support tool to estimate the value forest has for protecting buildings and infrastructure against gravitational natural hazards	✓		[7, 16, 17]
Economic routine TEGRAV (Technical - GReen – AVoidance) cost–benefit analysis of ecosystem-based, land use avoidance and technical protection measures (and their combination); TEGRAV is linked to the hazard model in FAT		✓	[18–20]
Direct costs originate from construction/implementation of a protection measure + maintenance + dismantling		✓	[18–20]
Indirect costs originate from the construction/ implementation of a measure, which presumably modifies an existing situation		✓	[18–20]

Research products	Main product	By-product	Ref.
Avoided damages are all detriments to infrastructures, people and assets that could occur without protection measures		✓	[18–20]
Benefits are the sum saved or earned due to the construction/implementation of the measure		✓	[18–20]
Rapid Risk Appraisal (RRA): Participatory approach for (i) pinpointing the most relevant natural hazards in terms of risk in a region, (ii) identifying strengths and entry points of risk management for implementing future risk reduction measures	✓		[8, 14, 15]
Risk identification identifying those natural hazards which are considered the most relevant from a risk perspective		✓	[8, 14, 15]
Risk analysis analyzing the existing risk management practices related to the previously selected natural hazards		✓	[8, 14, 15]
Risk evaluation generating and discussing the risk management profile on a spider diagram, which provides a comprehensive picture of risk management practices, and comparing risk management profiles for various study areas		✓	[8, 14, 15]
**Enables users to adapt the model (here the Flow-Py simulation tool) to address a specific question.*			

Table 1.
Catalogue of selected GreenRisk4ALPs research products for risk-based decision support in protective forest and natural hazard management.

daily or strategic activities. You can use the "Catalogue of selected research products" (**Table 1**) to select and include one or more (or parts of them) into your specific science-based and ecosystem-based risk management practice.

Before proceeding to the three steps needed for tailoring your own practice solution based on research results (subchapter 1.2), you must think about your willingness and ability to act realistically:

Willingness is linked to the tasks you are conducting and the interests you have. Both are individual and may differ from actor to actor. Yet, if interests and tasks are related to Ecosystem Services (ES; **Figure 1**), then the GR4A research products may attract your attention. Green prevention measures, as a regulating ES entail the maintenance, afforestation or reforestation of protective forests while technical prevention measures can be established in ecosystems to prevent or mitigate natural

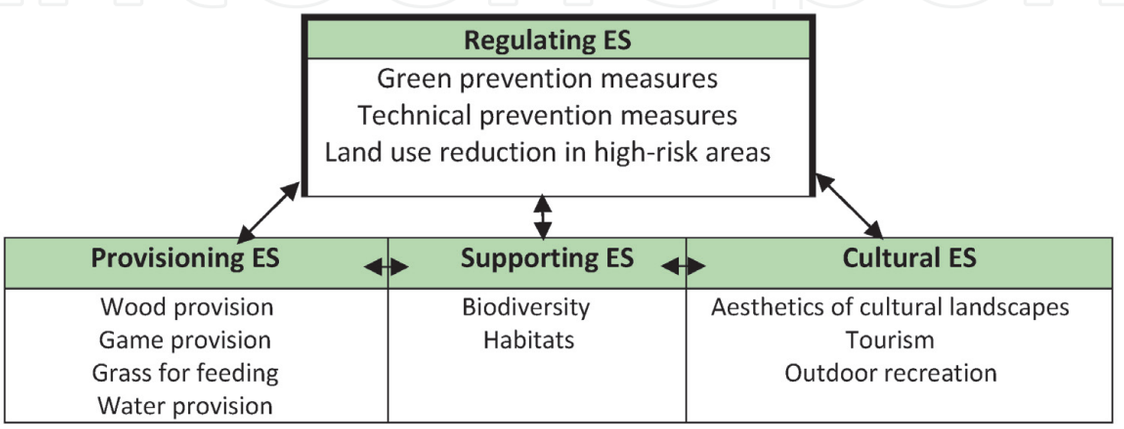

Figure 1.
Ecosystem services (ES) important in the context of ecosystem-based natural hazard risk management. Adapted from [21].

hazards whereas land use reduction in high-risk areas is an avoidance measure that changes the previous land use to reduce natural hazard risk (see GR4A project report [21]). Both technical and avoidance risk management strategies strongly influence ecosystems, affecting simultaneously also human well-being [22]. To visualize different tasks and interests of actors in risk management we summarized technical and avoidance strategies together with green prevention measures as regulating ES that influence natural hazard risk (**Figure 1**). Regulating ES are linked to the other ES categories: provisioning, supporting and cultural ES (**Figure 1**). Even if your work is focused on natural hazard and protective forest management, you are encouraged to think in terms of ES and try to identify those ES that are related to your area of interest and professional duty.

Ability is related to your realistic judgment of the resources at your disposal to engage in a particular activity. The most important resources and constraints (e.g., legal and economic ones) will be addressed here briefly, but no guide or Road Map can capture all the particularities of a single case. Therefore, the steps listed below are one way to realistically evaluate the implementation of scientific information and research results into your own applied project and its chances for success.

1.2 Three steps to integrate the GreenRisk4ALPs research products into your applied project or practice-related activity

For becoming part of an applied project or activity, scientific information selected from the "Catalogue of selected GreenRisk4ALPs research products" (**Table 1**) has to be integrated into the existing knowledge and experience of a particular actor [23]. Based on this new knowledge, practitioners can tailor their own projects or science-based activities in three basic steps. That is, you are encouraged to carefully consider each step and proceed to the next step if you answer most questions with a YES.

1.2.1 Step 1: diagnosis

Estimate the relevance of the GR4A research products for your risk management practice OR your ES-oriented forest use.

Main question: Is the particular GR4A research product relevant for my risk management OR my ES-oriented forest use in the Alpine Region?

Main aspects:
- relevance regarding my risk management (incl. political/economic setting)
- relevance regarding potential allies
- relevance regarding public goals

1A: Is the particular GR4A research product relevant for my risk management OR my ES-oriented forest use in the Alpine Region? Yes ☐ No ☐

You or your activities are part of the Alpine Region. You may be involved in forest management, civil protection, natural hazard risk management, live in a house or own a hotel protected by forests, operate or use highway or train infrastructure passing through endangered areas protected by forests. This direct object protective effect, which forest has to ensure for your safety or which is related to your occupation, is an example for the relevance and the key to answering whether

GR4A research products related with direct object protective forests are relevant for you. Also consider all three alternatives: (1) Green prevention measures, (2) Technical prevention measures, and (3) Land use reduction in high-risk areas (**Figure 1**). In addition, consider how risk prevention against natural hazards fits into your actual economic and political agenda. It may also be the case that the specific newly designed and scientifically based prevention strategy opposes your specific interest in using a forest. In this case you are free to dismiss scientific solution(s) fully or parts of the solution(s) that you do not accept. Not all scientific solutions are appropriate for all users.

1B: Is the particular GR4A research product relevant for my potential allies?	Yes ☐ No ☐

You may find it useful to think about networks of actors connected to the ES of your interest and then consider for whom your risk management or forest use might be particularly relevant. If you identify a potential ally, then the start of an alliance could improve the chances for success of your planned action. Yet, this potential ally (or allies) has to be interested also and open for the research product you are relying on. If you want to dismiss the scientific solution(s), then partnering with allies would mean that you can hinder the solution(s) and protect yourself from its potentially negative consequences.

1C: Is there a link between my risk management OR my ES-oriented forest use and the relevant public goal(s)?	Yes ☐ No ☐

Public goals are the backbone for national-to-global policies and basically governs us all. Linking (one or more) currently relevant public goals with your risk management or forest use may provide the highly required legitimacy for your applied project or action based on a GR4A research product. Therefore, it is advised to avoid legitimization by goals that are too unspecific such as the goal of sustainable forestry, because of their limited political reach. Instead, think widely! As a basis for your ideas, but more importantly also as a reference, you should consider goals introduced by national ministry programs or national strategies, well-acknowledged norms of a civil society or current and actual goals of international strategies. For example, the new EU Strategy on Adaptation to Climate Change [24] is calling for rolling out physical solutions for more green spaces (p.12) and to do it in a cost-effective way (p.11). Protective forests are green spaces and solutions that are having certain cost–benefit advantages compared to other hazard mitigation measures [22, 25]. While including protective forests into risk management strategies, either to stabilize the soil or to reduce impacts of natural hazards, the GR4A research products may not only have the potential to contribute to increasing people's safety but may also have a broader application as a climate-change mitigation measure. In contrast to immediately effective technical measures such as rockfall nets, Eco-DRR solutions have the potential to adjust to the challenges driven by global environmental change [26]. You must invest time and be creative to find out which strong public goals will serve your specific project and/or activity.

1.2.2 Step 2: consultation

Estimate the soundness of the scientific information provided by the GR4A research product that is relevant for you. Undertake this step only if most of your answers in the previous STEP 1 were YES ☑.

Main question: Is the relevant GR4A research product scientifically sound and available?

Main aspects:
- looking for "open doors" to science
- consulting scientific institutions / project teams about product limitations
- consulting diverse sources about credibility of research results
- selecting (parts of) products and consulting researchers for fine-tuning (if needed)

2A. Do I or my organization have connections to science? Yes ☐ No

First of all, check the ways your organization uses scientific information in daily practice. Are there specific open doors to science like working groups, scientifically knowledgeable collaborators or other persons experienced with science that work for your institution? Or, if you are a single person, think about how you are using scientific information in your daily life. Have you obtained science-based education or do you trust that your information about scientific results reflects the current state of knowledge? In any of these cases you should consider your existing links to scientific information. In general, such links are provided by the experts within your organization. These "integration forums" (for types see subchapter 2.2) may be either small or big, but they are essential to open the door to science [27].

2B. Can I or my integration forum check limitations of a particular research product(s)? Yes ☐ No ☐

The first task is to get into direct contact with the scientific organization(s) and its researchers who is offering a research product relevant for your risk management or ES-oriented forest use. Only through this direct consultation you will be in the position to get precise information that can help you to consider options for using this research product in a particular case. For example, if your tasks and interests are concerning the direct object protection provided by a particular forest, then you may want to check availability of maps of "Direct Object Protective Forest" for your region, or maps of "Efficient Green Mitigation Areas" (**Table 1**). All mentioned research products are based on scientific procedures and theoretical or data-based models, which are established within the scientific community, but they all have specific limitations. For example, models are limited in terms of included variables, available input data and uncertainties in their results (see chapters [3, 6, 28] of this book). However, the direct contact between you (or your integration forum) and the researchers will provide information into the underlying assumptions and limitations of the specific model. Based on this information, you can make a first evaluation about the suitability of its application to your needs and area of your interest.

2C. Can I or my integration forum check the credibility of research results? Yes ☐ No ☐

If you gained sufficient background information about the procedures that the research product is relying on and its limitations and you still consider including scientific information into your applied project or practice-related action, then you have to undertake the next step: to judge the scientific credibility of the research results. To do so, you can first consult organizations' websites while looking for indicators about the researchers who are offering the research product. Examples

for such indicators are research results that have passed the peer-review process of established scientific journals or the existence of networks with other researchers and institutions, especially with those you already know or have collaborated with [29]. As you may not always be in the position to judge the scientific quality of the research, you can ask another research institution for an independent evaluation. This is not only limited to the information from the websites but applicable for all sources, including various media channels (e.g., LinkedIn, Facebook or Twitter). These social media channels increasingly provide links to innovative research and results, yet their scientific basis must be checked before you can be certain about proceeding to the project implementation (Step 3). Checking means, for example, to be certain that the research results are state-of-the-art and evaluated by the scientific community through peer review. Diverse media channels communicate (scientific) information eye-catching and condensed, which is their basic mission, but they need to be cross-checked, at least with the original source and/or scientific publication.

2D. Can I or my integration forum check fine-tuning possibilities for (parts of) the research product of my interest?	Yes ☐	No ☐

The first three sub steps (finding open doors to science, checking product limitations and scientific credibility) will often not be sufficient to decide whether the particular research product fully fits your needs. Science can neither answer every specific question from practice nor provide comprehensive best-solutions. Therefore, you must identify the specific contribution of a research result to your interests or solution (e.g., calculating the likelihood of a natural hazard to reach a hotel or the costs for avoiding damages). Rarely, but it can happen that the scientific information fully supports your planned activity (no additional information is needed and no additional aspects must be covered). Then select it and use it as an argument for your planned activity or incorporate it into your own project. Typically, some additional scientific information will be needed, which might require time and resources to collect. If you have resources, then contact the researchers and ask to fine-tune the procedure, so that scientific accuracy remains intact. Sometimes, deficits of scientific information will appear too big. In that case, you may think to either initiate an additional research project or don't pursue your GR4A-based solution.

1.2.3 Step 3: implementation

Estimate chances for implementing your GR4A-based solution. Undertake this STEP 3 only if most of your answers in the previous STEP 2 were YES ☑.

Main question: Does my GR4A-based solution have a realistic chance to become implemented?

Main aspects:
- legal framework
- economic framework
- democracy and good governance

3A. Can my risk management or ES-oriented forest use be embedded into the existing legal framework?	Yes ☐	No ☐

Laws influence humans through enabling or restricting their actions. Therefore, check the legal basis for implementing your GR4A-based solution. If your ES-oriented forest use would, for example, increase costs for the protection measures for a municipality, then you might already look for financial instruments that particular policies might be offering and check if municipalities are eligible to apply. In addition, researching legal limitations is advised, because overcoming them later might be a long-term political process which can increase the timeline for implementing your solution.

3B. Can my risk management or my ES-oriented forest use be embedded into an existing economic framework? Yes ☐ No ☐

Risk management is costly, and cost-efficient solutions will save resources and open a broader room of action. Whatever your case might be, the issue of sufficient economic resources must be considered wisely, either while counting on private funding or having checked public funding sources (regional, national, international). In addition, public-private partnerships may be a funding option. Be realistic about the economic constraints for your project or your ES-oriented forest use. Project activities typically consume more resources than estimated. Thus, consider sources that may be available immediately or in the short term but look also for options in the longer term by clearly avoiding wishful thinking.

3C. Can my risk management or my ES-oriented forest use be embedded into good governance and democracy? Yes ☐ No ☐

Your GR4A-based risk management activity or ES-oriented forest use may be controlled by the law and/or available economic resources but paying attention to different strategies of good governance and democracy may enlarge your opportunities for actions. Involving multiple actors (as one of good governance principles) may, for example, raise the awareness about your problem or enhance the acceptance of your ES-oriented forest use. Participation of multiple actors may also increase political or economic support for your GR4A-based solution (see also chapter [30] of this book).

However, all participation processes related to risk governance are highly susceptible for conflicts, for example, driven by questions to what extent the costs that are covered by many will benefit only some. Past examples show that participation processes may result in shifts toward certain interests or cause a "crisis in governmentality" instead of governance. This may endanger the democratic legitimacy of your activity. Therefore, it is advised to first assess potential conflicts that your GR4A-based solution may mitigate, increase or additionally trigger. Depending on your assessment you might still find it worth to proceed. Then, finding professional support for handling multi-actor participation in risk-related issues may be advisable. Not only that these issues are prone to conflicts but the line between your goals (e.g., fostering participation for rising attention and transparency) and counterproductive effects of the participation process (e.g., triggering fear by the community members) is very thin and often better perceived and handled by a professional with experience in conflict management.

In addition, be aware that you are part of the democratic environment, which means that you must be transparent about your activities. Depending on your issue and your target groups you may use multiple channels for distributing information. If your aim is for a broader outreach, you may want to use digital and print media reaching a wider population. Or you may collaborate with the local media for very

locally specific issues. Tailored campaigns or public debates may also be a channel for spreading information. It is, for example, known from recent research that appropriate risk communication can trigger adaptive behavior (see chapter [31] of this book). Yet, for triggering such effects, you have to bear in mind that the inputs and research products used for risk communication need to be carefully considered. In this context, the modeling results from the GR4A project might be useful, for example, when trying to raise the awareness of laypersons about wider benefits of protective forests such as their benefits for mitigating climate change. Or to highlight the impacts that adaptations of protective forest management practices will have on biodiversity (e.g., selection of tree species and dead wood management). Otherwise, laypersons can hardly imagine the impact and importance of protective forests and their functions and effects on the life and livelihood in the Alpine Region.

1.3 Checklist for the successful implementation of tailored, applied risk management projects

For your final evaluation for using research product(s) offered by the GR4A project (**Table 1**), go through Step 1 to Step 3 again. They are summarized in form of a checklist below (**Figure 2**). Let these steps and their associated questions guide you, so that you arrive at a realistic estimation of your chances to solve a particular risk management problem or to realize your ES-oriented forest use in practice. The more positive answers you give, the better the chances are for the successful implementation of your tailored, applied risk management project or practice-related action. Good luck!

This Checklist is intended to be used by stakeholders in practice. For the opposite case that scientists want to use a guide for fostering the support of practice for their research, please look into our "Road Map for decision targeted communication of green risk management" [32].

Figure 2.
Checklist for the successful implementation of tailored, applied risk management projects.

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2. Theoretical and methodological background of the Road Map

2.1 The RIU model

The RIU model is a theoretical model of knowledge transfer created in 2016 [29]. Stevanov and Krott [23] provide an explanation and anchor the model within the three phases of knowledge transfer: the most recent overview from [33] discriminates between (i) linear models (in the 1960s) where knowledge was expected to be implemented linearly by politicians and bureaucrats; (ii) co-production and other models (in the 1970s–1990s) where attention was drawn to the active part that politicians and bureaucrats can play while interacting with scientists and bringing their political judgements to the knowledge transfer; and (iii) embedded models (after 2000), where an even more active part of practice is offered and, in addition to the input of politicians and bureaucrats, explicit formats for societal input are provided. The RIU model belongs to the third group of embedded models, which try to enrich solutions and include public interests and values, while simultaneously keeping scientific knowledge as the basis. The RIU model accordingly acknowledges two distinct elements – Research (R) and Utilization (U), each following its own, different rationale. That is, research follows the formal, public rationale, and scientific information is generated to describe and explain real world phenomena. Utilization, on the other hand, does not rely on the rational (deliberative) discourse, but rests upon the power to induce change in practice, which serves the interest(s) of the dominant actors. Within the processes of transferring scientific information from the Research into forestry practice (Utilization), the scientific rationale as well as interests and power of actors from practice remain separate (**Figure 3**). Yet, the bridge between them is established through Integration (**Figure 3**) and its integration forums respectively [27].

2.2 Methodological background

The Road Map is a result of a theory-based analysis that was empirically proven by the GR4A project. Empirical evidence was collected by the means of observation, document analysis and expert interviews [34]. This evidence was crosscut (triangulated) for reliability purposes [34]. The theoretical basis of the Road Map builds on the key criteria of knowledge transfer summarized by the checklist of [29]. These key criteria of knowledge transfer were tested between 2016 and 2018 within the ALTERFOR project and its ten case study areas [35]. Results led to the further development of the theoretical basis and further adjustment of the key criteria (see [23]). Based on that, the PARs of the GR4A project [9] served to deepen the analysis

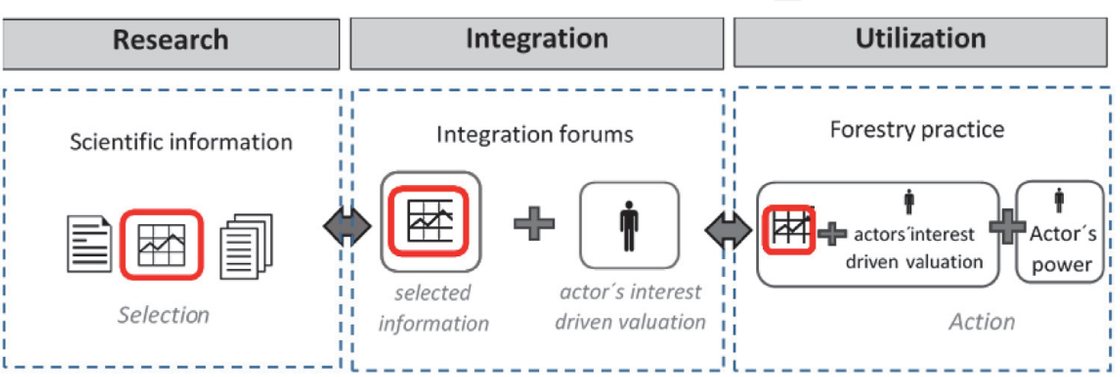

Figure 3.
The RIU model: transfer of scientific information from research into utilization by practice via integration. Adapted from [23]; for "Integration forums" see [27].

Integration forum				
Type	**Defining elements**			**Examples**
	Forum is identified as already existing	**Forum has existing links to science (gradual)**	**Forum is known by the project**	
Existing	+	+	+	• Advisory boards • Jurisprudence
Hybrid	+	+	-	• Bilateral discussion • Expert rounds • Ad-hoc task forces
New	-	+	+	• Workshops • Round tables

Table 2.
Defining elements for each type of an integration forum (yes +, no -): existing, hybrid, new forums. From [27].

and to look into the processes driving the selection of scientific information and the modes of exchange with the actors from practice. These different modes of information exchange, called integration forums [27], were investigated in all PARs. The three types of integration forums – existing, hybrid and new forums - were determined (**Table 2**) while using the following characteristics [27]: (i) if the forum has been identified as an already existing one (yes +, no -); (ii) if the forum has an existing link to science (yes +, no -), and (iii) if the forum is known by the research project (yes +, no -). Examples for each type of integration forums are given in **Table 2**, and details can be found in GR4A project reports [36, 37]. This knowledge on different types of integration forums is useful for Step 2 of the checklist where the scientific fit of research products is checked (see subchapters 1.2 and 1.3).

3. Discussion and concluding remarks

The RIU model represents a comprehensive knowledge transfer approach [29]. Each of its three elements - Research, Integration and Utilization - is related to specified tasks of knowledge transfer and backed up by empirical evidence. Empirical evidence from the GR4A project [36–38] as well as several other cases [39] shows that the transfer of scientific information from science into practice works best when both scientists and practitioners keep their specific, independent roles but strongly engage into the mutual communication.

In this mutual communication, scientists and practitioners come together to exchange information within particular integration forums [27]. For transferring scientific information into practice, workshops have been often recommended and applied within research projects [40–44]; however, workshops have been proven to be rather ineffective [45, 46]. This is because a workshop does not attract powerful actors and as such does not represent a place where relevant decisions are (or could be) made.

Most knowledge transfer models suggest continuous improvement of communication processes between researchers and actors from practice, aiming at a general consent [47, 48], that is, practitioners should be fully integrated into the research process. Such co-production approaches are often found in EU project calls, i.e., for multi-actor projects [49]. Based on the RIU model, however, we did not find empirical evidence showing that full integration of practitioners into the research will lead automatically to more successful knowledge transfer (Utilization), which

has also been confirmed by other authors (e.g. [50, 51]). According to the RIU model, integration forums are not all-inclusive but selective with respect to relevant actors [27]. If integration aims for the general consent between science and practice regarding the content of the science-based solution, then it can be expected that the communication process will typically "hurt" both the scientists as well as the relevance of the solution for the practice. Furthermore, we did not find empirical evidence showing that mutual learning can help scientists by switching into the role of practitioners and vice versa, as it is proposed by most knowledge transfer models up to now.

To summarize, growing knowledge transfer efforts are positive developments. We offer a Road Map that was developed within the GR4A project for integrating research products into the risk management solutions of practice (see subchapter 1.2). We found that the project duration of three years resulted in innovative research products but has been proven to be too short for establishing the process of integrating these results into practical solutions effectively. In contrast to the expectations of many scientists and research funding programs the process of knowledge transfer is a long and bumpy road and needs considerable time and resources, which should be addressed more comprehensively in the future.

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Conflict of interest

The authors declare no conflict of interest.

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