Karst Commission

M I K A S

(Most Important Karst Aquifer Springs)

Guidelines for the Selection of Springs

Background/ Project Objective

Springs are important for the humanity because they provide potable water to many locations in the world, thus ensuring health, sanitary conditions, food production and economic development. Karst and mineral water springs are particularly significant, but springs that emerge from karst aquifers are by far the largest – some are even discharging entire underground rivers, with flows that sometimes exceed 100m^3/s. Many springs are also historically important or represent cultural heritage in concerned countries.

The project "Most Important Karst Aquifer Springs" or MIKAS has been launched at the annual meeting of the Karst Commission (KC) of the International Association of Hydrogeologists (IAH) during the EUROKARST conference held in Malaga, Spain in June 2022. The project aims to bring together both the KC members and many national experts (NEs) to work, on a voluntary basis, to establish the list of important springs, create the Code of Practice for their utilisation and protection, and promote the springs by labelling them *in-situ* and publicising them on the Internet.

The objective is, thus, to make the most important springs in the designated countries attractive for scientific and tourist visits, widely promote them, and protect them from possible deterioration. Finally, the MIKAS list(s) and obtained data will be made available to the public, and the proposals could be submitted to national governments and institutions to provide support for *in situ* labelling and protecting of these "water pearls", if such actions had not been already taken.

The project will be widely advertised and promoted through the website, leaflets and a published monograph with final results.

Organisational Setup and Mechanism

The project's Advisory Board (AB) consists of KC members and regional representatives, namely: John Gunn (Western Europe and Oceania), Zoran Stevanović (South-eastern and Eastern Europe), Junbing Pu (Asia), Seifu Kebede (Africa), Neven Kresic (North America) and Augusto Auler (South and Central America). The KC IAH is represented by three rotated Chairs - Avihu Burg, Peter Malik and Benjamin Tobin - while the UNESCO IHP is represented by Alice Aureli and Aurélien Dumont. The project coordinator (team leader) is Zoran Stevanović, who initiated this project.

In the 6-month period that lasted from July to December 2022, two AB online meetings have been organised to discuss some of the organisational and conceptual aspects and how the project should proceed. The main conclusions from these meetings helped create these Guidelines, which are supposed to facilitate the work of national experts in selecting springs and providing information on their characteristics and values.

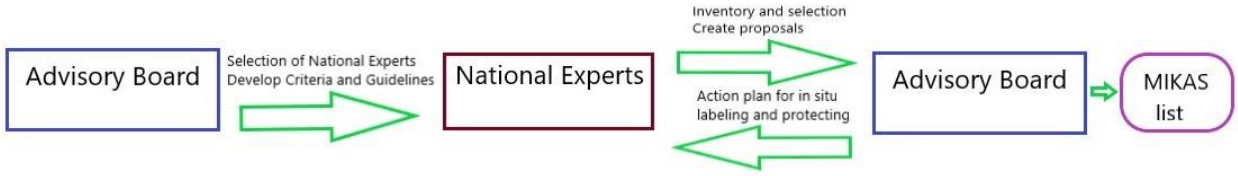
In accordance with regional representation, members of AB will be responsible for identifying and communicating with national experts. Since the project has been launched by the IAH KC, members of this organisation will be primarily invited to join the team that will be working on the project; however, as the number of countries with a presence of karst is significantly greater than the number of countries represented in the KC, many colleagues – hydrogeologists, karstologists, hydrologists or geographers who are working in karst or dealing with its problems – would also be invited to contribute to MIKAS.

More than one expert from the countries with a large presence of karst and springs could be invited to act as NEs, requiring some sort of consensual proposal. Even when only one expert from a concerned country is invited, he will be free to invite other researchers to help him in identifying and selecting the springs. Such assistance is welcome as it provides guarantees for a

good quality proposal - “The more eyes, the better”. Acknowledgements in all project documents would be certainly given to all NEs and their collaborators.

The MIKAS is a fully voluntary project under the auspices of the IAH Karst Commission. Therefore, no funding is envisaged for travelling and the working hours of national experts. The project is seeking to obtain UNESCO IHP support, but should some funds become available they will probably be symbolic and used primarily for establishing and maintaining a MIKAS website, publishing promotional materials, and possibly for in-person meetings of the project’s Advisory Board. Therefore, all the activities of national experts should be based on evaluation and presentation of existing data and knowledge.

Proposals prepared by the NEs would be ultimately evaluated by the AB responsible for the creation of the final MIKAS list. A simple organogram of the project can thus be presented in the following form:



Categories of Springs

The project was initially launched with the idea to select only springs that have a global significance, and to make a unique MIKAS global karst springs heritage list. However, during the AB meetings the idea was brought forth to create two lists instead: one of the most important springs at the global level – MIKAS, and the other of springs that are more significant nationally than internationally. While the first would be established by the decision of the AB following the proposals of the NEs, the second would be decided by the NEs. Therefore, the second list could be called NIKAS (Nationally …). This way, we would avoid a potential unfavourable situation where the AB could disregard NE’s justification, leaving some precious springs without recognition. In addition, this would provide a real opportunity to NEs to make a rigorous selection and include in the MIKAS list some truly great springs based on the established criteria (see next Chapter).

The lists should be created based on common criteria, but should also be adapted to local conditions and recognition of specific circumstances of each country. Something that is important in one country does not have to be important in others. Some large “karst” countries such as USA or China may have more than five, or even ten springs, while others may have just one or two, maybe even none at all that would meet the MIKAS criteria. Although we currently cannot estimate the number of candidates for the second (NIKAS) list, there is a question of how many springs we would like to include in the main MIKAS list. The AB has concluded that the number should not exceed (roughly) 200. As an approximated average, this would imply about 1.5 per each UN member country that has some karst on its territory. However, during the project implementation we will be able to adjust these figures and come to the final solution. The same applies to the NIKAS list. However, a flexible approach does not mean that the list should be indefinite.

Selection Criteria

The selection criteria are the following:

- Historic (H),
- Aesthetic (A),
- Economic (E),
- Scientific (S),
- Ecological (Es).

H - There are numerous springs in the world that have historic and/or cultural significance. They have caused the establishment of many permanent settlements and nearby cities, essential for local nations and their communities' development.

A - The aesthetic criterion is always problematic, as *de gustibus non est disputandum*. However, something like a waterfall, an enormous cliff or a big cave behind a spring should commonly be judged as a nice and acceptable landscape for one of the two lists.

E - The economic-management value should primarily consider the spring's active use. Spring water can be used for potable water supply, irrigation, or for supplying the local industry. Some "economical" springs issuing from karst aquifers are also used for generating hydropower, providing geothermal energy, or are applied in balneology and recreation. Even if not tapped, water from karst springs maintains the baseflow of important rivers or fills large reservoirs. In a few words, a spring can support local economy by generating food and income to the local community or the country as a whole.

S - The scientific value may consider specific discharge mechanisms of the springs such as large maximal yield, intermittent flowing, gas bubbling, changing water quality in coastal areas (fresh, brackish and saline) or some other properties that could be of research interest to the hydrogeological science.

Es - Water from karst springs can sustain sensitive ecosystems, especially those with endangered species. It could also flow through protected areas, such as the Ramsar site, or some other environments of significant biological, ecological or hydrogeological interest.

To facilitate the standardisation in evaluating karst springs, in the initial stage of the project a proposal was made to establish an algorithm which would somehow enable their more objective selection and ranking. Such a preliminary algorithm gave slight advantage to the first three criteria, namely H, A and E. However, to facilitate the work of the NEs, it was decided at the AB meeting to apply a simpler procedure, i.e. "Expert's Opinion", instead of assigning numerical value, which still remains an optional solution.

Along with a Survey for each of the springs, the NE should propose the list for which the spring would be a candidate (MIKAS and/or NIKAS) and provide justification for such a potential decision. Justification should be more detailed, as well as illustrated, for springs that are proposed for the MIKAS list.

The Survey Form

Although it was initially planned to have as much complete information about the proposed springs as possible, the AB simplified the final Survey i.e. Inventory Chart in order to get a good response from NEs and facilitate their work. Therefore, the Survey consists of mandatory basic information for each of the proposed springs, while other information is optional.

It would be useful to include any readily available data in the "mandatory information" section. However, if information is not readily available, a note may be provided thereon, including a simple 'N/A'. In other words, the "mandatory" information requirement is not a deal breaker. If it is not available, it does not mean that the spring will be automatically excluded from one of both lists. For example, if the spring is tapped (captured) for certain use(s), but the information on the quantity (quantities) used is not readily available, denote this by marking it as 'N/A'.

Location and Hydrogeological Setting

Along with the basic information about the spring's name and location (country, region, city or village, basin), it is important to submit its coordinates using the World Geodetic System WGS84 standard. Coordinates N and E should be given in degrees, minutes and seconds. This is also the standard for the Google Earth Map, where proposed springs should be pinned and the extract map submitted either as figure in Survey form or sent as file in .jpg format to the AB, i.e. regional coordinator. In this way, even springs without the in-the-field readings by GPS could be reversibly labelled. If there is no geodetic determination, the spring's altitude could be read from the Google Earth Map. The final MIKAS database would thus contain standardised values, and each spring could be easily located on the Google Earth Map.

Hydrogeological data should include a description of the dominant lithology and the prevailing stratigraphic age of the aquifer system. The use of the International Stratigraphic Chart is recommended for the latter, but it is also possible to use local classification with a clear reference to the geological period and epoch (e.g. Upper Jurassic). Further data should include the spring's discharge rates in litres per second, measured or estimated (minimal/average/maximal). For the classification of the spring's type, it is suggested to choose one of the two offered options in three domains: permanent or temporary character, gravity or ascending flow, issuing cold or thermal ($>20^0$C) water. However, other typology by use of some of the well-known classifications (e.g. Gunn, 2004; Ford & Williams, 2007; Springer & Stevens, 2009; Kresic & Stevanović, 2010) is also possible, but should contain a clear reference to these or another information source. Specific characteristics of the spring, e.g. discharge mechanism, transboundary character, specific discharge mechanism, or similar, should be noted as well. The same applies to the presence of important or unique karst features in the catchment area (caves, other springs, swallow holes, gorges, numerous sinkholes) that give an additional value to the analysed spring and its environment.

If the spring is tapped (captured), piped and actively used, the following data may be provided if it is readily available: intake structure (briefly explained, e.g. a simple concrete box around (or over) the drainage point, dammed drainage point, structure with a few collection chambers, capture with cut-off walls); average pumping hours (h/day) and pumping rate (l/s); for tapped springs, it is important to distinguish the amount of used water and overflow, which equals ecological flow. Both should be expressed in l/s, as an average rate or min/max range of yield. If the spring is not tapped, or is tapped just for *in situ* use (without water distribution to distanced consumers), this should be clearly stated, disregarding the above information. However, the number of local consumers or water dependants may also be approximated.

Presentation of groundwater quality should include multiannual averaged (or range of values) data on physical characteristics (temperature, turbidity), water mineralisation (TDS or EC), pH and hardness. Concerning dynamic regime of karst groundwater would be preferable to present seasonal average values, if they exist.

There should also be information about the actual spring protection, such as the existence of sanitary protection zones, a fenced narrow protection zone around the tapped spring, and so on.

Spring Importance / Criteria

It is recommended to provide comments regarding each of the five criteria and clearly explain which of them is considered the most important. Therefore, the NE should rank these criteria in an order, from those that were the most relevant for the proposal, to those of lesser significance. This would be a good place to provide a more detailed justification for proposing a specific spring based on most relevant criteria. If needed, use an additional sheet for the explanation.

It is also required to state whether the spring in question is already recognised by the authorities as a nature reserve and deserves protection due to its importance for the nation.

The final proposal for a spring to be included in the MIKAS (globally important) or NIKAS (nationally important) list should be placed in this section.

References and Information Sources

This section may provide up to 10 most relevant references about the spring. The references should include those that validate its historical or cultural importance, its characteristics such as geomorphology, hydrology, geology and hydrogeology, but also sources referencing the spring and its water, such as fairy tales, legends, travelogues or guidebooks.

Graphics

The NE should provide an image (preferably in a .jpg format) in the form of an extract of the Google Earth Map with a pinned spring(s). It would be nice to share a couple of photographs of the spring, as well as some of the important features in its basin. The captions should be provided for each photo, along with authorship credits.

Optional Data

The NE may also provide some of the following data, if they are known and available:

- The grading criteria for proposing springs (it is an option to grade each of the five criteria, using grades from 1 to 5);
- Approximated size of the catchment, presented in km^2;
- Groundwater chemistry (major ions and regime of quality - fresh, brackish, saline, mineral);
- Threats to spring water quality (this should include data on the main actual or potential pollutants).
- Additional graphics may include extracts of existing maps, preferably hydrogeological or geological, but also geographical maps showing the estimated catchment area and the spring itself. A schematic hydrogeological map may include main roads, settlements, litostratigraphical units, rivers and main water points, with a scale, map orientation and a legend for used symbols. A provided cross-section over the analysed spring would be an advantage, especially for springs to be included in the MIKAS list. A representative spring hydrograph and typical chemical analysis could be provided as well.

In case of tapped (captured) springs, the following information may be provided:

- Water distribution system (e.g. pipe's diameter and length to the first reservoir or delivery point, pumps or gravity transport, reservoirs – number and types);
- Purpose(s) for which water is used (drinking, irrigation, small industry, hydropower, heating, combined);
- Number and types of beneficiaries (based on Utility data, or approximated: population, livestock (big/small), orchards (type and size, presented in *ha*), agriculture land (crop and *ha*), number of industrial objects connected, energy produced);
- Water treatment applied (e.g. only chlorination, ozonisation, filtration…).

Some of the above information may vary greatly throughout the year or may not be easy to collect. For instance, in many karst springs, the pumping rate and overflow (ecological flow) change significantly over time (seasonally as well), requiring an approximation. The NE may roughly indicate his level of confidence in provided data by using asterisks (*, **, ***) with an explanation in the footnote, e.g. uncertain, probable, very probable, or expressed in percentage points.

* * *

The collection of required information should not be overly complicated. While preparing the inquiry form, the AB tried to create a balance between the simplest possible form (given that the work of NEs is voluntary) and the requirement to collect relevant information specifically for the database which will be open to the public. If some exact information is missing, the space should be left unpopulated or marked 'N/A'; however, an estimation should be provided whenever possible. Therefore, please provide as much information as you can but an incomplete form for an important spring is better than the spring not being recorded.

Two practical questions were raised during the AB consultations. They concerned springs that are already utilised and those that are still relatively unknown.

In the former case, responsible persons in water utilities or even NEs might not be willing to provide technical information about tapped springs for security or other reasons. But generally, the idea of MIKAS identifying important springs does not imply prevention of their further use. On the contrary, the aim of the initiative is to highlight their importance, defend them from possible devastation, and ensure that any further intervention takes into account their protected status. In case a spring is actively used for water supply, which would necessitate its greater protection, it should still be able to be visited by organised groups during designated time slots. However, if concerns regarding presenting information about such springs persist, such "hidden" springs should be excluded from valuing.

In the latter case, when a spring is known only to a narrow group of specialists and meets neither the condition of scientific importance nor any other criteria, such a spring should also not be included in either of the two lists.

Finally, the NE should objectively and independently estimate both the global and local (national) importance of the karst springs he wants included in the MIKAS or NIKAS list, as this will make the final selection and decision of the AB easier.

Further Steps - Spring Protection and Promotion

The *Code of Good Practice* for important springs should be prepared in the next stage of the MIKAS project. The *Code* would follow the aim of the project to:

- Highlight the springs' importance,
- Defend them from possible devastation, and
- Ensure that any further intervention takes into account their protected status.

The results and achievements of the project would thus be available to a wider public. One of the ideas involves the creation of standard panels containing basic information (in local languages as well as in English) about the springs, their history and importance, morphological characteristics, discharge mechanisms and other specific facts. The content and form of these unique panels should be discussed in later stages of the project. The AB and NEs should discuss ways to reach national government bodies and ask them to support the placement of informative panels in the field, at the site of the springs.

To conclude, the point of the MIKAS project is not to make long lists, but to identify the most important springs in each of the "karst countries" and propose that they be labelled, better protected and used in a sustainable manner. Many springs and their surroundings are attractive for scientific and touristic visits, and such geoheritage sites could generate funds for local communities. Their wider, planned promotion will certainly increase the awareness of their significance and the need to better protect them from deterioration.

Appendix

(Survey Form)