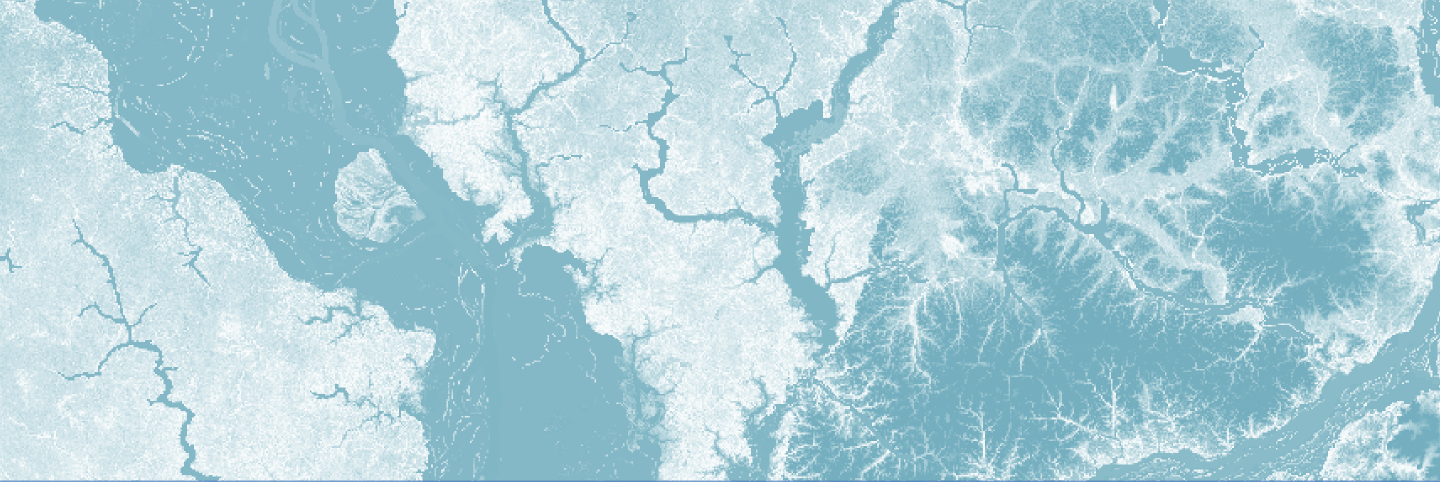


# Groundwater Assessment Platform

www.gapmaps.org

eawag
aquatic research

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

# An online GIS platform to assist management of naturally contaminated groundwater

*Groundwater serves as drinking water for around 50% of the world's population and is indispensable for irrigation and food production in many regions. Over-abstraction, pollution and changing climatic patterns are all factors leading to groundwater stress. In terms of drinking water quality, groundwater is usually less affected by pathogens than surface water. However, naturally occurring (geogenic) contaminants such as arsenic and fluoride affect many aquifers, with serious long-term health effects for those consuming the water. The Swiss Federal Institute for Aquatic Science and Technology (Eawag) has refined a method whereby the risk of geogenic contamination in a given area can be estimated using geological, topographical and other environmental data without having to test all groundwater wells. This knowledge is now available free of charge on the online Groundwater Assessment Platform (GAP).*

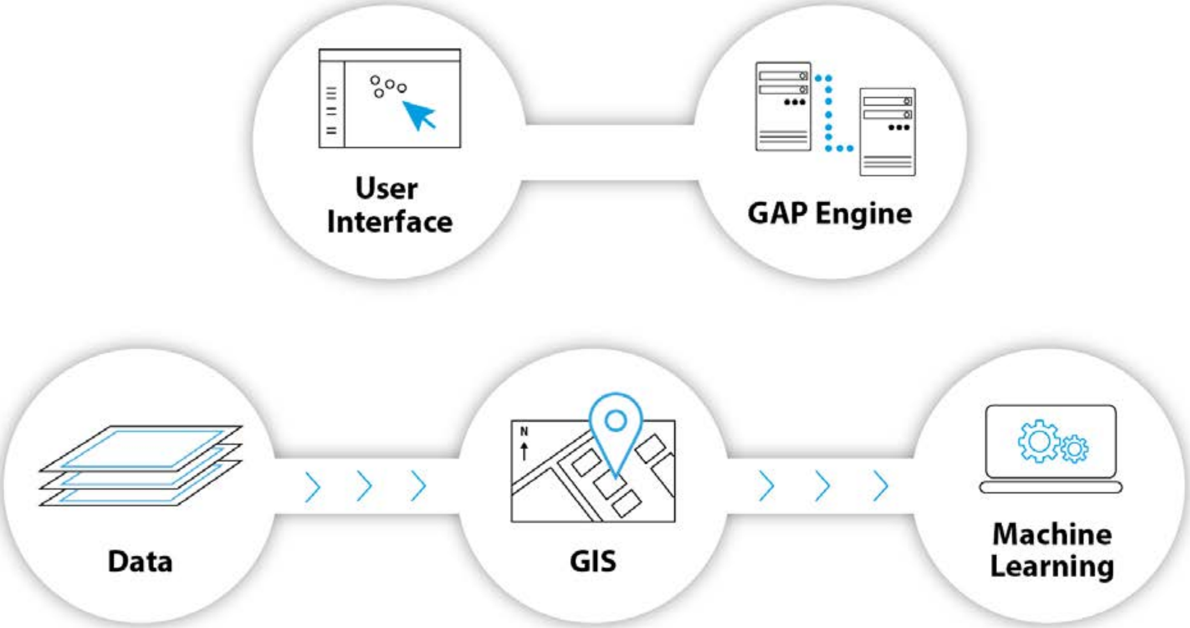
Shallow drinking water tube well in the Red River Delta, Vietnam, a region that is affected by naturally occurring (geogenic) arsenic contamination of groundwater

## WHAT IS GAP?

The Groundwater Assessment Platform (GAP), accessible via **www.gapmaps.org** is an interactive GIS portal for mapping and modelling of groundwater contamination and other environmental hazards. It serves to inform researchers and practitioners about contaminant hazards and mitigation options, and provides tools for viewing, analysing, sharing and modelling one's own data.

## WHO WE ARE

GAP was developed by a group of water quality experts and geospatial modellers at Eawag, the Swiss Federal Institute of Aquatic Science and Technology. We build on more than ten years of experience in the predictive statistical modelling of geogenic groundwater contaminants and in developing and promoting innovative mitigation options.




The main components characterising the Groundwater Assessment Platform (GAP)

## OUR VISION

GAP's long-term aspirations are summarised in the following vision statement:

> *"To assist communities, national and international institutions, civil society and research organizations in having access to maps, data and relevant information to enable all people and the environment to have an equitable right to safe groundwater."*

By monitoring and raising awareness of groundwater quality problems, GAP contributes to achieving the UN's Sustainable Development Goals (SDG's), in particular SDG 6:


- ***6.1 – access to safe drinking water***
- ***6.3 – pollution and hazardous chemicals***
- *6.4 – water scarcity*
- *6.5 – integrated water resources management*
- ***6.B – community involvement in water management***

Daily drinking water collection at a communal tube well drawing water with elevated arsenic concentrations, Burkina Faso

## TARGET GROUPS OF GAP:

- *Authorities, policy makers*
- *Planning agencies*
- *Water utilities*
- *Researchers*
- *NGOs*
- *International organisations*
- *Private sector*
- *…*

## BENEFITS AND IMPACTS OF GAP

A new level of water quality assessment

Targeted deployment of resources for water quality testing

Prioritise high-risk regions

Monitoring tool for achieving SDG 6

Bring together stakeholders working on groundwater quality

Intensify and encourage research efforts in contaminated regions

Improve and protect public health

## GAP FEATURES

GAP's main functionality is data visualization, mapping, modelling and information dissemination and sharing, which are implemented by means of four main components:

### 1 GAP Maps

- Freely accessible online GIS
- Global and regional contaminant prediction maps
- Geology, soil and climate data for viewing and printing

### 2 Statistical modelling

- Logistic regression modelling of point data (e.g. water quality parameters)
- Predictor variables provided by GAP and/or the user.
- User account ensures security of personal data

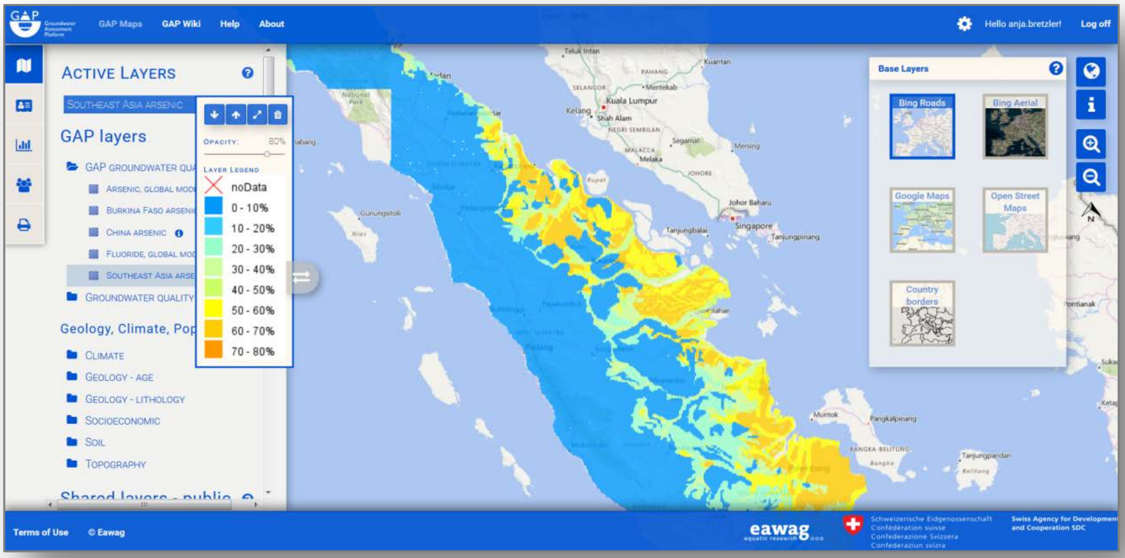
### 3 User communities

- User-created and managed communities
- Facilitate collaboration in a secure environment
- Data, models and notes only shared within a community

### 4 GAP Wiki

- Information exchange platform
- User contributions on focal topics
- Features the “Geogenic Contamination Handbook”

GAP’s online GIS interface, allowing the visualisation of data layers over various base map layers. Pictured: predicted arsenic hazard in groundwater on the Indonesian island of Sumatra (Winkel et al., 2008)



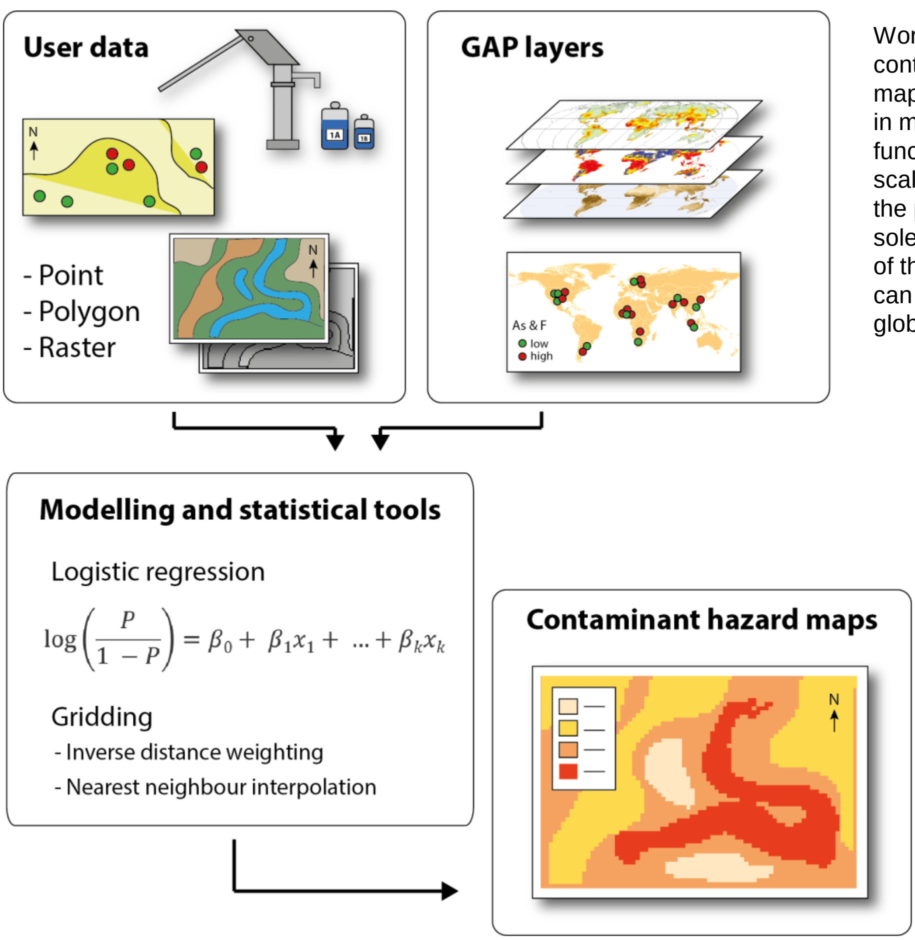
## PRODUCING HAZARD MAPS FOR CONTAMINANTS

Analysing groundwater for geogenic contaminants such as arsenic and fluoride is time-consuming and costly. Maps highlighting areas with a high contamination hazard can aid decision-makers in undertaking more targeted drinking water surveys.

Innovative methods for producing such maps have been developed, essentially involving the correlation (logistic regression) of groundwater quality point data with geospatial datasets of predictor variables (e.g. geology, soil or climate).

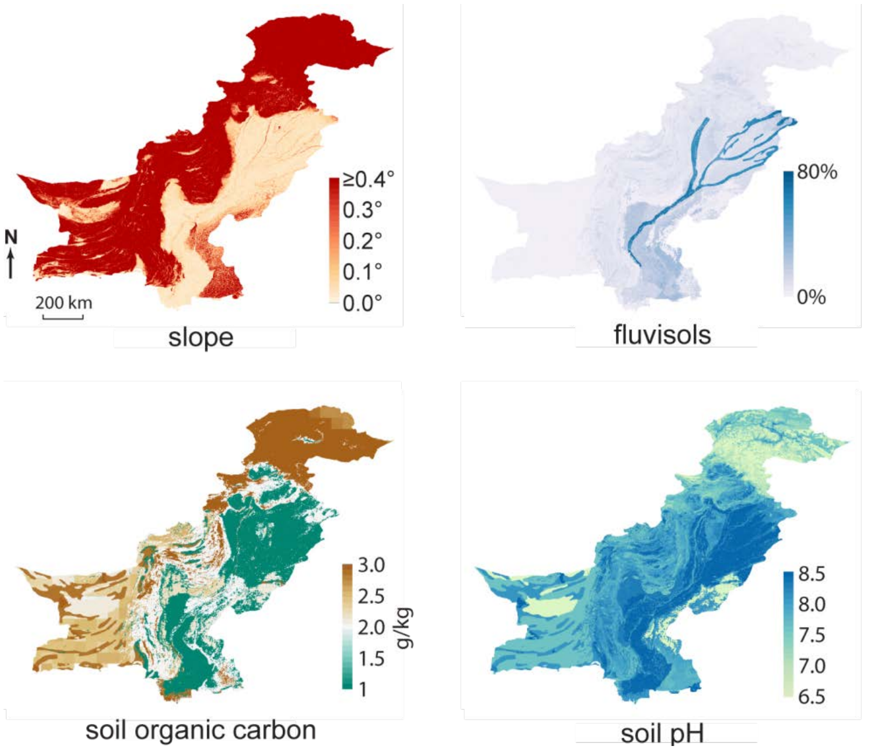
The accuracy of these predictive models has been demonstrated in various countries, for example Vietnam, Indonesia (Sumatra), China, Pakistan and Burkina Faso (Winkel et al., 2008; Rodriguez-Lado et al., 2013, Podgorski et al., 2017; Bretzler et al., 2017).

GAP facilitates the development of such maps by providing the necessary statistical modelling framework and built-in datasets (GAP public layers). Users can also upload their own data to produce hazard maps of their contaminant and area of interest.

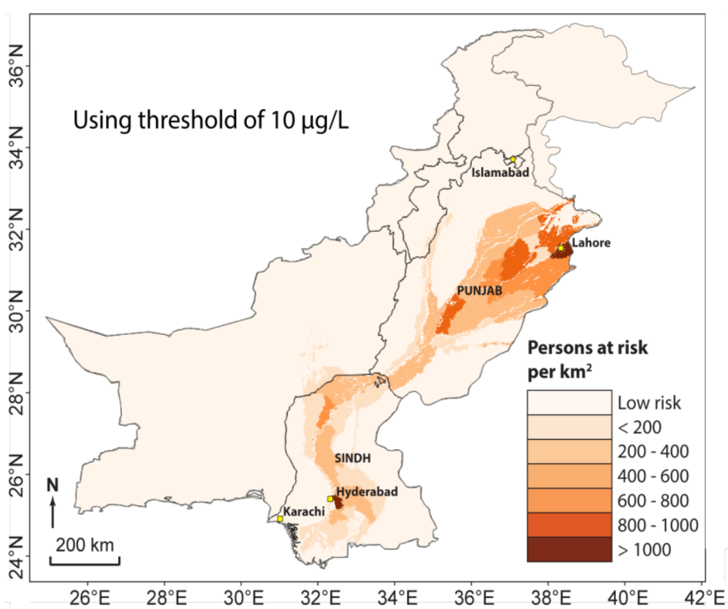



Workflow for producing contaminant hazard maps using GAP's built-in modelling functionalities. The scale and resolution of the produced maps solely depends on those of the input data and can range from local to global scale.

Examples of spatially continuous predictor variables that are used as input data for contaminant hazard maps, in this case for the prediction of arsenic-affected areas in Pakistan (Podgorski et al., 2017).

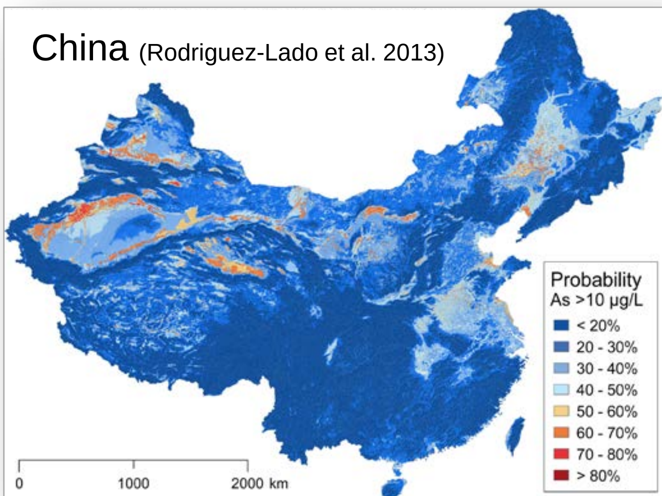



Population density coverages are freely available in GAP. In combination with the produced contaminant hazard maps, they can be used to provide estimates of the number of people potentially affected by the investigated contaminant. Here: persons at risk of drinking arsenic-contaminated groundwater, Podgorski et al. (2017).



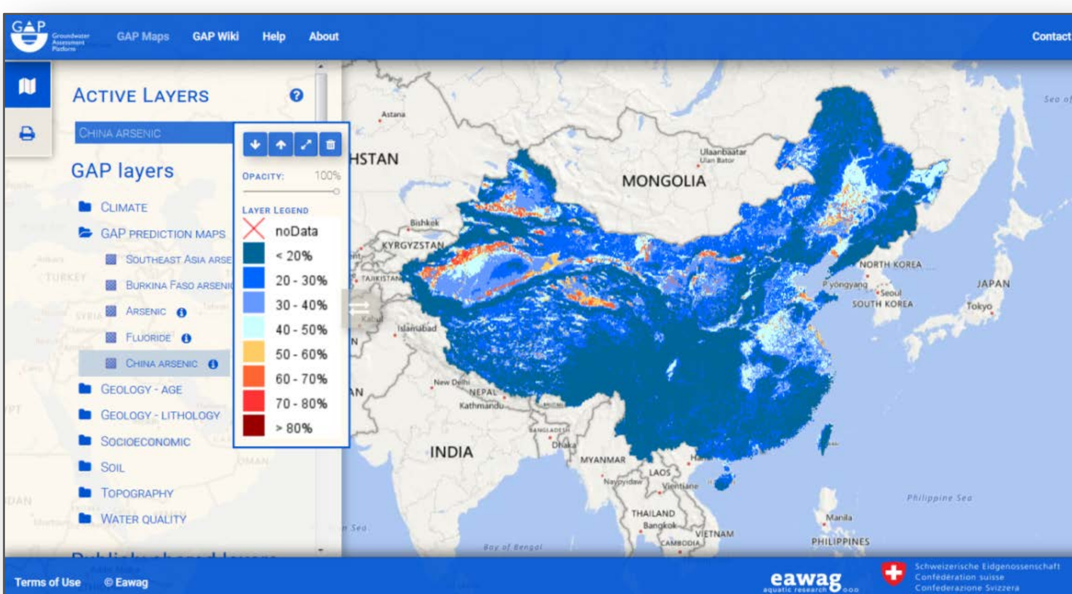
## HAZARD MAP EXAMPLE

The built-in modelling framework, allowing users to produce hazard maps with their own (or GAP-provided) data, is a unique feature offered by GAP. Hazard maps of groundwater contaminants produced via time-intensive manual coding and published in peer-reviewed scientific journals (e.g. Rodriguez-Lado et al., 2013; Podgorski et al., 2017) have been reproduced using GAP's online and freely available modelling functionalities with greatly reduced time and effort.




Hazard map showing the modelled probability of groundwater arsenic concentrations exceeding the WHO drinking water guideline value of 10 µg/L in China. This map was produced "offline" via manual coding.

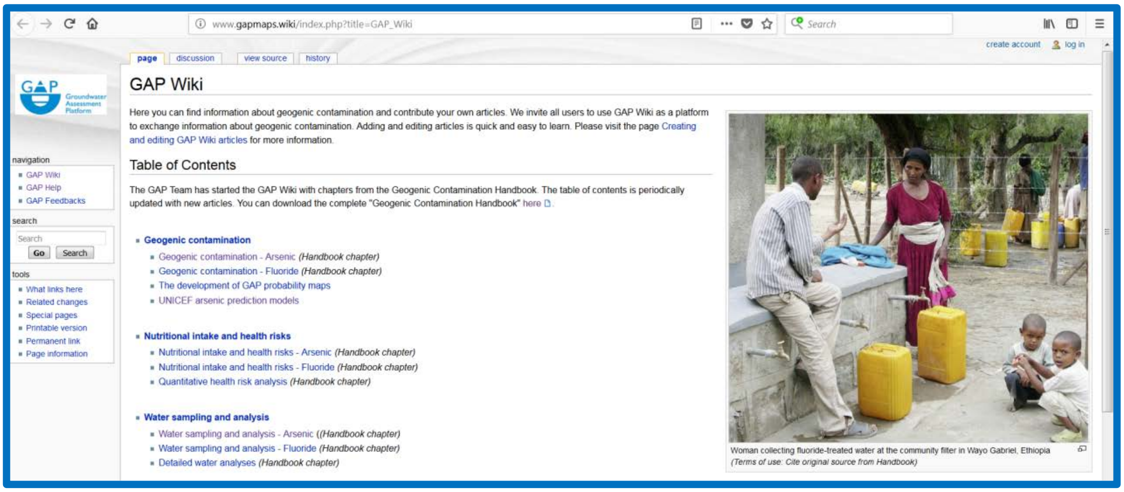
Nearly identical hazard map produced with considerably less time and effort using GAP's built-in logistic regression modelling functionalities. The same datasets were used as for the map shown above.



## PROFESSIONAL COMMUNITIES

GAP is not only an online repository for groundwater quality-related data, but also serves as a platform for data sharing and information exchange. With the "Community" functionality, users can create and manage user groups, which can facilitate data sharing in a secure environment, fostering collaboration on specific case studies.

The GAP Wiki features information on various topics related to groundwater quality and successful mitigation: water sampling and analysis, treatment technologies, financing mechanisms and techniques to induce lasting behaviour change. Contributions by users are encouraged and moderated by GAP staff.




The GAP Wiki information exchange portal, accessible at www.gapmaps.org

## WHO USES GAP?

The services of GAP – mapping, modelling, information exchange – are aimed at a diverse group of stakeholders and cater to different interests and needs. Currently, users from 140 countries have registered on GAP and come from a variety of sectors, including academia, government, NGOs, the private sector and industry.

# USEFUL LINKS AND ORIGINAL PUBLICATIONS

Amini, M. et al., (2008a) Statistical modeling of global geogenic fluoride contamination in groundwater. Environmental Science and Technology, 42(10), 3662 – 3668, doi:10.1021/es071958y

Amini, M. et al., (2008b) Statistical modeling of global geogenic arsenic contamination in groundwater. Environmental Science and Technology, 42(10), 3669 – 3675, doi.org/10.1021/es702859e

Bretzler, A. et al. (2017) Groundwater arsenic contamination in Burkina Faso, West Africa: Predicting and verifying regions at risk. Science of the Total Environment, 584-585, 958-970, doi:10.1016/j.scitotenv.2017.01.147

Podgorski, J.E. et al. (2017), Extensive arsenic contamination in high-pH unconfined aquifers in Pakistan. Science Advances, e1700935, doi:10.1126/sciadv.1700935

Rodríguez-Lado, L. et al. (2013), Groundwater arsenic contamination throughout China. Science, 341(6148), 866 – 868, doi:10.1126/science.1237484

Winkel, L. et al., (2008) Predicting groundwater arsenic contamination in Southeast Asia from surface parameters. Nature Geoscience, 1, 536 – 542, doi.org/10.1038/ngeo254

Winkel, L. et al., (2011) Arsenic pollution of groundwater in Vietnam exacerbated by deep aquifer exploitation for more than a century. PNAS 108(4), 1246-1251, doi:10.1073/pnas.1011915108

Groundwater Assessment Platform (GAP): www.gapmaps.org

GAP video: https://www.youtube.com/watch?v=ClBqe53LFxY

Geogenic Contamination Handbook: https://www.eawag.ch/en/research/humanwelfare/drinkingwater/wrq/geogenic-contamination-handbook/

Eawag: Swiss Federal Institute for Aquatic Science and Technology: www.eawag.ch

Swiss Agency for Development and Cooperation (SDC): https://www.eda.admin.ch/sdc

## THE POTENTIAL OF GAP

Initially, GAP's focus has been on groundwater quality, especially the geogenic contaminants arsenic and fluoride. However, the online GIS interface, logistic regression modelling framework and Wiki exchange platform are features that can be applied equally well to different data and topics. We envision broadening the scope of GAP to subjects such as

- Contaminants in soils and food crops
- Surface water quality
- Groundwater recharge

*Are you interested in using GAP for your geospatial project? Contact us if you have any questions!*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