# Airing Ideas

## Summary of SEARCH II results and conclusions

SEARCH II

School Environment
and Respiratory Health
of Children

The SEARCH initiative is supported by the Italian Ministry for the Environment, Land and Sea (IMELS)

# The SEARCH initiative

## The context

The SEARCH initiative, School Environment and Respiratory Health of Children, is a research project implemented within the international frameworks of the EU Action Plan on Environment and Health; and the European World Health Organization's Children's Environment and Health Action Plan for Europe. SEARCH also contributes to the European legal and policy framework for sustainability in schools, since children's health and educational potential depend on the quality of the school environment.

The first phase of the SEARCH initiative, the SEARCH I project (2006–2009), led to the creation of a comprehensive environment and health database through environment and health assessments in selected countries. Based on the SEARCH I conclusions and recommendations, the initiative was reaffirmed at the Fifth Ministerial Conference on Environment and Health, which was held in Parma, Italy, in 2010. In keeping with the recommendations contained in the Parma Declaration, SEARCH II (2010–2013) was developed, expanding the SEARCH initiative geographically to four new countries from the EECCA region (Eastern Europe, the Caucasus and Central Asia) and extending the overall scope of the research.

## The project

SEARCH II involved 10 countries: six in Europe (Albania, Bosnia and Herzegovina, Hungary, Italy, Serbia and Slovakia) and four in the EECCA region (Belarus, Kazakhstan, Tajikistan and Ukraine). The project had three components: environmental, health and energy use monitoring; environmental health assessment; and energy and comfort assessments in all 10 countries. The project comprised designing environment and health capacity-building programmes for school staff and training on local implementation strategies. Recommendations were made for improving the school environment, buildings and energy consumption, based on an analysis of data from schools in the 10 participating countries.

## Goals and objectives

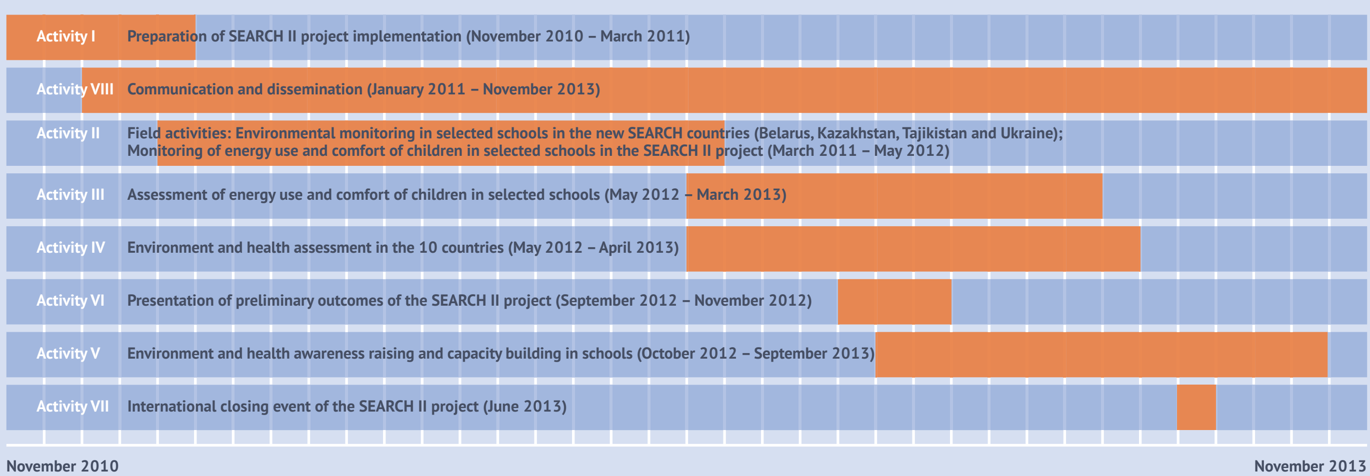
The SEARCH II project aimed to:

- extend the geographical scope of the SEARCH initiative to Belarus, Kazakhstan, Tajikistan and Ukraine in order to assess the relationship between the school environment and children's health in a broader context;
- analyse environmental and health data from 10 countries (Albania, Belarus, Bosnia and Herzegovina, Hungary, Italy, Kazakhstan, Serbia, Slovakia, Tajikistan and Ukraine);
- introduce a new initiative for assessing energy use in school buildings and the impact of building materials on children's health;
- compile recommendations for improving the quality of school environments and school buildings and improving energy efficiency based on an analysis of data from the 10 countries; and
- strengthen successful awareness-raising initiatives from the SEARCH I project for the prevention of respiratory diseases, particularly among children, with a special focus on school buildings and energy use.

## Countdown to success

- 10 countries
- 101 schools
- 6,758 children assessed
- 55 international experts
- 37 months of project implementation
- 5 months of field activities
- 10 months of data analysis

**TIMELINE.** SEARCH II comprised eight main project activities that were translated into the project implementation process and divided throughout the three-year project implementation period (November 2010 to November 2013).



## Identifying connections

The environment and health assessments were carried out in order to evaluate associations between the school environment and children's health in 10 countries. Assessments were carried out in Albania, Bosnia and Herzegovina, Hungary, Italy, Serbia and Slovakia under SEARCH I (between October 2007 and March 2008); and additionally in Belarus, Kazakhstan, Tajikistan and Ukraine under SEARCH II (between October 2011 and April 2012).

The two-part study comprised:

- an exposure assessment (measurement of indoor air quality in schools, assessment of school buildings and maintenance, and assessment of the home environment); and
- an assessment of children's health status via a symptom questionnaire and lung function measurements (using spirometry).

Measurements were taken of formaldehyde, volatile organic compounds (benzene, toluene, ethylbenzene and xylenes), carbon monoxide (CO), nitrogen dioxide ($NO_2$), particulate matter ($PM_{10}$) and carbon dioxide ($CO_2$); and of two characteristic indoor air parameters – temperature (T) and relative humidity (RH) – inside each classroom. Levels of the selected pollutants were measured inside and outside schools in participating countries during the heating season.

In the various countries, mean concentrations of pollutants were in the following ranges: $PM_{10}$ 28 to 102 µg/m$^3$; $NO_2$ 12 to 22 µg/m$^3$; benzene 1.95 to 7.4 µg/m$^3$; ethyl-benzene 0.8 to 1.82 µg/m$^3$; toluene 4.9 to 27.6 µg/m$^3$; xylenes 4.3 to 9.1 µg/m$^3$; and formaldehyde 1.73 to 33.07 µg/m$^3$.

Figure 1 shows levels of the monitored component that is most harmful in terms of respiratory health – that is, $PM_{10}$. The high indoor concentrations measured in most of the countries can partly be explained by the fact that 40 percent of the schools are in areas with high or very high traffic density. The relationships between indoor and outdoor concentrations show that the main source of $NO_2$ and $PM_{10}$ is ambient air, and that formaldehyde is primarily from indoor sources (Figure 2).

## Health status of children

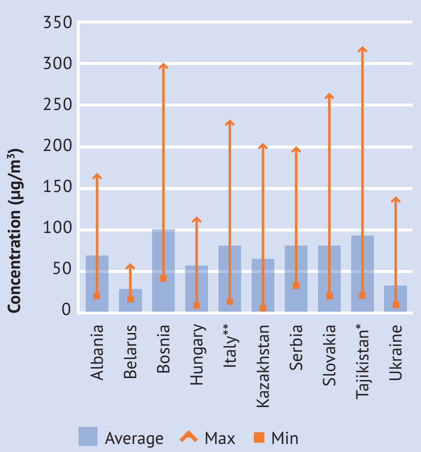
Children's health was evaluated according to responses to a questionnaire completed by the parents. Parents were asked whether their child usually had a cough (a sign of bronchitis) in autumn/winter; had had various symptoms of asthma (wheezing) in the previous 12 months; and was sensitive to any allergens, as confirmed by a doctor.

## Links between air pollution and children's health

An asthma symptom (wheezing after exercise) was significantly associated with concentrations of indoor $CO_2$ measured in the classrooms. Children in classrooms with $CO_2$ concentrations above 2,000 ppm were exposed to an 88 percent higher risk of wheezing after exercise, compared to those in classrooms with lower indoor levels of $CO_2$ (Figure 3).

The mean floor space in this study was 2.02 m$^2$/child. Overcrowding (less than 1.5 m$^2$/child) in the classroom resulted in a significant increase in the measured indoor concentrations of several pollutants, including $CO_2$, benzene, toluene and $PM_{10}$. In overcrowded classrooms, significantly more children suffered from respiratory tract diseases than in those with more space.

**FIGURE 1.** Indoor $PM_{10}$ concentrations measured in classrooms in the 10 SEARCH countries during school hours




*5-minute sampling
**24-hour sampling

**FIGURE 2.** Relationship between concentrations of pollutants measured inside classrooms and outside the school in the 10 SEARCH countries

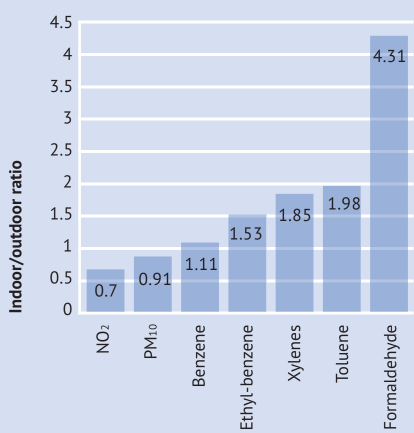
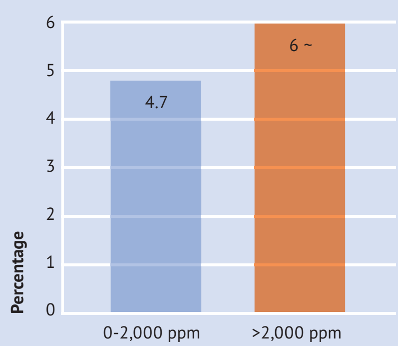



**FIGURE 3.** Prevalence (%) of children wheezing after exercise in classrooms with indoor concentrations of $CO_2$ below or above 2,000 ppm




cOR=1.88*** (95% CI: 1.30–2.70)
Corrected for age, gender and country
~ p<0.1; ***p<0.001

# Comfort assessments: Summary of results

## Collecting data

The comfort assessment evaluated perceptions of comfort among children in the 10 participating countries (the SEARCH II monitoring period was October 2011 to March 2012). Children's comfort is an important personal indicator of the quality of the indoor environment. This is particularly true of thermal comfort, which depends on temperature, humidity and ventilation in the classroom. Air quality has a significant impact on the performance of children in the classroom, and is implicated in health risks. Greater frequency of headaches, for example, is associated with an uncomfortable indoor environment. Levels of $CO_2$ are an indicator of ventilation rate and, in general, of overall indoor air quality.

In all 10 countries, a questionnaire survey was carried out in the participating schools during the heating season with the aim of assessing perceptions of comfort among the children using simultaneous measurements of temperature, humidity and $CO_2$ concentrations. The pooled database from the 10 countries was analysed by the National Institute of Environmental Health, Budapest, where STATA/SE 10.0 software was used for the statistical analysis. The results were then finalised by the Italian and Hungarian expert team.

Altogether 6,758 children aged between 8 and 12 years participated in the study: 49.1 percent girls and 50.9 percent boys. The average amount of time spent in the classroom was 24.4 hours per week.

## Results of the comfort assessment

The distribution of responses related to perceived air temperature is shown in Figure 4. Only 7 percent of children felt that the classroom was not warm enough, while 48 percent of pupils thought that the classroom was warmer than optimal, and 44.7 percent considered the temperature to be adequate. Figure 5 shows the measured temperature in degrees Celsius.

The prevalence (percentage) of children with headaches in relation to perception of air quality in the classroom at the moment of questionnaire completion is shown in Figure 6. Significantly more children had a headache among those who considered the air quality to be bad (27.2 percent) or even neutral (20.9 percent) than among those who felt the air quality was good (16.9 percent). As girls complained significantly more frequently of headaches (21.8 percent, compared to 17.6 percent of boys), and younger children had headaches more frequently than older ones, after adjustment for gender and age logistic regression analysis revealed that in poor-quality air the risk of headaches increased by 96 percent, and by 31 percent even with neutral air quality, compared to good air quality.

**FIGURE 4.** Pupils' perception of indoor air temperature according to questionnaire responses

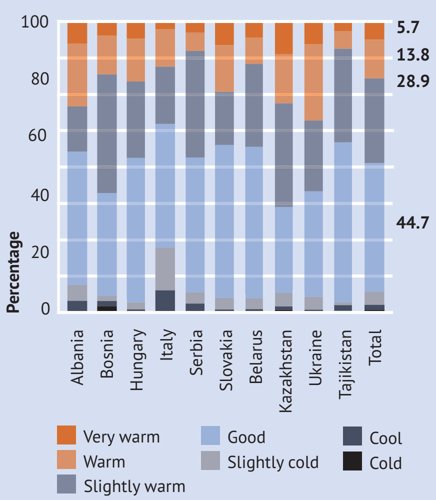



**FIGURE 5.** Measured mean temperatures (ºC) in relation to perceived air temperature in the classroom

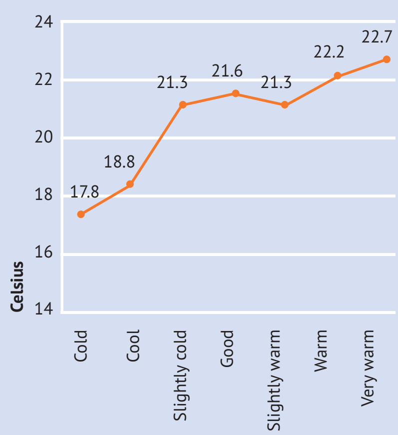
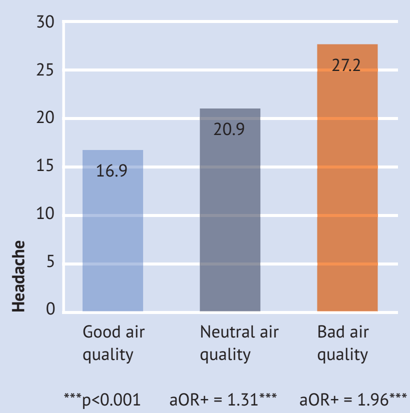



**FIGURE 6.** Prevalence (%) of children suffering headaches compared to perception of air quality in the classroom



## The study

The energy component assessed energy consumption in the 10 participating countries. National energy experts gathered relevant information from the schools during field visits. Data were collected on building size; construction; heating, hot water, cooling and ventilation systems; as well as annual heat and electricity consumption.

In most of the analysed schools, the thermal characteristics of the building structure were very poor. The average heat transfer coefficient for the external walls was 1.28 W/m$^2$K, and for the roof 0.97 W/m$^2$K. However, in many schools the U values were even lower – for example 2.6 W/m$^2$K for walls and 1.81 W/m$^2$K for the roof. In relation to doors and windows, the situation was slightly better due to the fact that windows had been renewed in several of the schools. The average heat transfer coefficient of the windows was 2.57 W/m$^2$K. Over half the analysed schools were connected to a district heating system, mainly in Belarus, Kazakhstan, Serbia, Slovakia and Ukraine. A quarter of the schools had constant temperature boilers, and 10 percent of the analysed buildings featured oil or coal boilers. Only 5 percent of the schools used condensing boilers for heating (Figure 7). There were slight differences among the participating countries in the method used to calculate overall building energy performance, therefore a common calculation method was chosen. Calculations were made according to the Hungarian 7/2006 TNM Decree, which is in line with the implementation of the Energy Performance of Buildings Directive (EPBD). In the first calculation, all buildings were assumed to be situated in the same location. The specific heat loss coefficient and primary energy needs were then calculated. Two indexes were created, school by school, to compare buildings from the point of view of thermal characteristics: a building envelope index ($q_i$) and an energy index ($e_i$).

## Results of the energy assessment

The building envelope index of a given school is the rate of the calculated value of the specific heat loss coefficient of the school and the reference value of the specific heat loss coefficient (Figure 8). Generally, the calculated specific heat loss coefficient was 1.64 times higher than the reference value. The energy index is the rate of the calculated value of the total primary energy of the given school and the reference value of total primary energy. The average primary energy consumption of the 95 schools was 220.9 kWh/m$^2$a. Generally, the calculated primary energy consumption was 1.7 times higher than the reference value, therefore it can be concluded that the modernisation of the building structure and the heating, ventilation and air conditioning (HVAC) systems has very large energy-saving potential. In the second calculation, in which the energy consumption of buildings was calculated by means of the actual location, the calculated and real energy consumption were compared and the values were close to each other (Figure 9). The simulation models of the buildings are therefore considered useful for further investigations.

**FIGURE 7.** Heat production

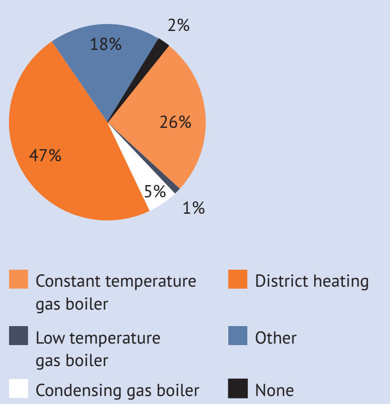



**FIGURE 8.** Building envelope index (qi) per school

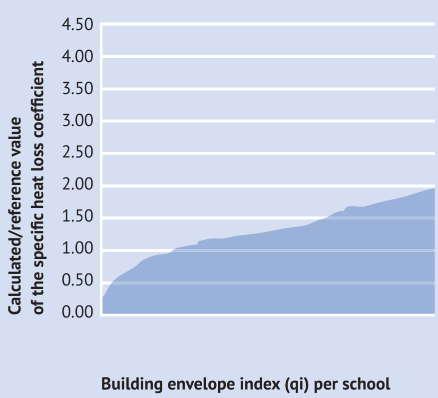
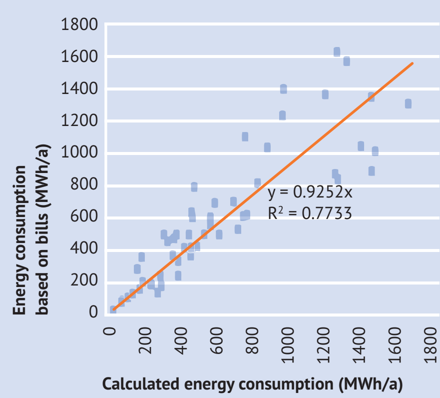



**FIGURE 9.** Calculated and real heating energy consumption



# SEARCH II conclusions

## Environment and health

- The database created under SEARCH I and II, containing data for 7,860 children from 388 classrooms in 100 schools in 10 countries, represents a unique opportunity to study a wide variety of school indoor and outdoor environments; outdoor and indoor concentrations of several air pollutants; and associations between the school environment and children's health.
- Indoor concentrations of $NO_2$ (and of $PM_{10}$ to a lesser extent) were found to be due to outdoor pollution sources (mainly traffic), while volatile organic compounds and formaldehyde were mainly emitted by indoor sources.
- The health status of children from the various countries was widely assessed. It was observed that symptoms of asthma and doctor-diagnosed allergies were significantly less frequent in the four new SEARCH II countries than in the six SEARCH I countries. This observation is in line with earlier findings on the difference between East and West Germany in the 1990s and can be explained by the effect of "Western lifestyles".
- Due to the large database, it was possible to find several statistically significant associations between the school environment and children's health. Some of these associations may be accidental and difficult to interpret, but most provide useful information and well-documented facts that can be used to determine new interventions in order to ensure a more healthy school environment and improve children's respiratory health.
- Some examples of effective interventions are obvious from the results, such as: avoiding overcrowding in the classrooms; opening windows regularly during every break and after each lesson; keeping some windows open during classes; and avoiding plastic (PVC) flooring and water-resistant paints. Schools should not be built next to busy roads or in areas heavily polluted from other sources.

## Comfort

- Further evidence was found that good air quality during lessons depends significantly on the ventilation regime during breaks. There were significant differences in the perception of air quality during breaks in the classrooms, corridors and courtyards, while most children (41 percent) spent breaks inside the classrooms.
- Objective measurements of temperature, relative humidity and $CO_2$ levels supported the children's subjective perceptions.
- 48 percent of pupils considered their classroom to be warmer than optimal (children felt the air temperature to be too warm above 22°C). This finding may be significant in terms of energy saving.
- Significantly more children suffered from headaches among those who considered the air quality to be bad (27.2 percent) or even neutral (20.9 percent), than among those who felt the air quality to be good (16.9 percent). After adjustments for gender and age, logistic regression analysis revealed that with bad air quality the risk of headaches increased by 96 percent, and even with neutral air quality the risk increased by 31 percent, compared to good air quality.

## Energy

- Recommendations were made for the modernisation of building structures and HVAC systems.
- The specific heat loss coefficient, building envelope index, total primary energy consumption and energy index were calculated after modernisation, school by school.
- As a result of modernisation, the average specific heat loss coefficient would decrease from 0.49 $W/m^3K$ to 0.19 $W/m^3K$, and the average building envelope index would fall from 1.64 to 0.66.
- Average total primary energy consumption would decrease from 220.9 $kWh/m^2a$ to 108.0 $kWh/m^2a$, thus average potential energy savings are more than half the primary energy consumption.
- The improved thermal characteristics of the building envelope would ensure lower heating energy consumption, and at the same time improve the children's sense of comfort.

## Improving policies

The SEARCH II project working paper explores the potential to improve current policies in order to protect IAQ by preventing the release of hazardous chemical pollutants from consumer products, including furnishing, flooring, building materials, cleaning products and air fresheners. These are less well known sources of pollution that school and office managers and home owners should take into account in order to improve indoor air. Temperature, ventilation and humidity also affect IAQ by influencing reactions and concentrations of chemical pollutants and encouraging the growth of harmful moulds.

The European Commission and researchers are working towards a harmonised framework for product labelling schemes in the EU that support requirements related to health, safety and the environment under the Construction Products Directive (89/106/EEC) and the subsequent Construction Products Regulation (305/2011/EU). However, a question remains regarding environment and health synergies and the promotion of good IAQ: Is a healthy indoor environment also a concern in sustainable consumption and production policies, which are the cornerstone of the renewed EU Sustainable Development Strategy?

The SEARCH II working paper, which was published at the end of 2013, identifies potential links between sustainable consumption policies and IAQ by addressing the following questions:

- **Is IAQ taken into consideration in the environmental impact assessments performed in relation to sustainable consumption and production policies?**
- **How is IAQ addressed in energy-saving policies?**
- **How is IAQ assessment managed at country level?**

The SEARCH II country partners responded to an ad hoc questionnaire in order to share knowledge and best practices and raise awareness among local stakeholders.

The working paper also covers the potential co-benefits for consumer health and market competitiveness of implementing IAQ protection in sustainable consumption and production policies.

## The main sustainable consumption and production policies

| Ecolabel Scheme | Green Public Procurement (GPP) | Environmental Technologies Action Plan (ETAP) | Ecodesign Directive |
|---|---|---|---|

## Project partners

**The Regional Environmental Center for Central and Eastern Europe (REC)**
**Project Manager:** Anita Kocic
**Email:** AKocic@rec.org

Eva Csobod
Peter Szuppinger
Reka Prokai

**Italian Trust Fund (ITF)**
Stefania Romano
Valerio Ponzo

**Italian Ministry for the Environment, Land and Sea (IMELS)**
Elisabetta Colaiacomo
Stefania Romano
Alessandra Burali

**Italian National Institute for Environmental Protection and Research (ISPRA)**
Luciana Sinisi
Francesca De Maio

**Catholic University of the Sacred Heart (Italy)**
Umberto Moscato
Andrea Poscia

**Fondazione Salvatore Maugeri (Italy)**
Margherita Neri
Lucia Iannacito

**Independent international energy expert (Italy)**
Julio Calzoni

**Pecs University; Comfort Consulting Ltd. (Hungary)**
Zoltan Magyar
Gabor Nemeth

**National Institute of Environmental Health (Hungary)**
Peter Rudnai
Eva Vaskovi

### SEARCH II national coordinators in the project countries

**Albania**
Eduard Cani
REC Albania

**Belarus**
Tatiana Pronina
Republic Scientific-Practical Centre for Hygiene

**Bosnia and Herzegovina**
Lejla Schuman
REC Bosnia and Herzegovina

**Hungary**
Reka Prokai
REC Head Office

**Italy**
Luciana Sinisi
ISPRA

**Kazakhstan**
Tatiana Shakirova
Regional Environmental Centre for Central Asia (CAREC)

**Serbia**
Zorica Korac
REC Serbia

**Slovakia**
Katarina Halzlova
Slovak Public Health Authority (PHA)

**Tajikistan**
Malika Babadzhanova
Regional Environmental Centre for Central Asia (CAREC)

**Ukraine**
Olena Turos
O. M. Marzeiev Institute of Hygiene and Medical Ecology of the National Academy of Medical Sciences

This updated edition has been produced to summarise the final project outcomes, which are available at **search.rec.org/outcomes**

MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE

REGIONAL ENVIRONMENTAL CENTER

FONDO FIDUCIARIO ITALIANO
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