

Environment and Health Research in China: The State of the Field*

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Abstract

In the context of this symposium, this article reviews social science research in the emerging field of environment and health in China, with a particular focus on the impacts of pollution. It begins with a discussion of the particular nature of China's environment-related health problems, distinguishing the different challenges presented by diseases of poverty, affluence and transition. It then reviews recent developments in policy and civil society with regard to environment and health, and the extent to which work in the social sciences has advanced our knowledge of these and of state–society interactions. The article concludes with some reflections on the need for and challenges of interdisciplinary and international collaboration in this area.

Keywords: environment; health; regional development; governance; interdisciplinary research; China

Until quite recently, no one would have thought of “environment and health” as a field of research within China studies. Yet, this is the second collection of articles on the topic to appear in the space of three years, and in concentrating on public perceptions of and responses to the impacts of pollution on health, it already shows the sharpening of focus characteristic of a developing research field.¹ This growing scholarly interest reflects the emergence of environmental impacts on health, and the direct and indirect effects of pollution in particular, as a fairly discrete issue of government and public concern. From a smattering of reports and articles ten years ago,² it has steadily gathered steam, appearing with increasing frequency in government, international organization and media reports, and academic publications.³

It is increasingly becoming clear that this constitutes the appearance of a new “problem field” in the sense that the impact of pollution on health, and the societal demands it is generating, cannot be adequately addressed within existing legal and policy arrangements.⁴ They require the development and implementation of a new policy agenda within and beyond the environment and health sectors, and the generation of new formal and informal institutions and norms for structuring the often conflicting interactions between the many actors involved.

This article begins with a short discussion of pollution-related health risks, where they fit into the broader spectrum of environment-related health problems in China, and the new challenges for research and policy presented by the fact that the “diseases of transition” span multiple policy streams and disciplinary boundaries. It continues with a discussion of the sources of our patchy knowledge about the extent of pollution's effects on health and its distribution across locations and populations. On the basis of this, I review recent developments in policy and civil society with regard to environment and health, and the extent to which work in the social sciences has advanced our knowledge of these and of

* This work is supported by the Rockefeller Brothers Fund.

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related state–society interactions, pointing out some opportunities for further research along the way. I conclude with some reflections on the need for, and challenges of, interdisciplinary and international collaboration in this area.⁵

China’s Environment-related Health Problems

The interaction between environmental factors and human health is notoriously complex. In both English and Chinese, the term “environment” (*huanjing* 环境) includes both physical and social dimensions, which interact in dynamic ways with individual and community level characteristics and behaviours. The impact of environmental factors on health can be immediate or long term, proximal or distal; and individuals are often exposed to a complex combination of hazards over the course of time, rendering the establishment of cause–effect relations extremely difficult.⁶ For these reasons, environment and health problems present governance challenges of a generic nature that must be distinguished from those that are particular to the Chinese setting.⁷

At the same time, the constellation of specific environment-related health problems that a country faces at a given time is closely related not only to enduring aspects of the local terrain and climate, but also to past and current patterns of production and consumption, livelihoods and lifestyles.⁸ As a country undergoing rapid changes in economic, social, cultural and political life, and with people in rural and urban areas in different parts of the country living and working in vastly different physical and social conditions, China faces a particularly complicated set of environment and health challenges. It must cope with “traditional” environmental impacts on health associated with poverty; an increase in “transitional diseases” related to rapid industrialization and urbanization; and what are known as “the diseases of affluence,” all at the same time. These problems are often layered upon each other in the same physical space, for example when rural residents are exposed both to indoor pollution from burning solid mass fuels and to heavy metal pollution from industry. Migration, which is central to processes of both economic and social change, compounds the complexity of exposure.⁹ Each of these problems presents different challenges for governance, and also relates to international experience in different ways.

Although rapid economic growth in the post-reform period has increased incomes and life expectancy (it reached an average of 73 years in 2007¹⁰), China continues to face the environmental health problems associated with poverty. The burning of solid fuels for heat and cooking, poor sanitation and hygiene, and uneven access to healthcare services, all contribute to the persistence of respiratory, infectious and bacterial diseases, malnutrition, and maternal and infant mortality, especially in the west of China.¹¹ However, these problems are generally on the decline and China has made considerable progress towards meeting the health-related Millennium Development Goal (MDG) targets by 2015.¹² These illnesses are also relatively straightforward in terms of causation, mostly have fairly rapid onset, and are generally amenable to intervention through investments in sanitation infrastructure and public health initiatives at the household level.¹³ They therefore do not present a particularly new challenge for governance; while they reflect, and also contribute to, social inequalities, for the most part they do not involve strong conflicts of interests or provoke new types of social tension. As with poverty alleviation more generally, many see China’s experience in addressing these problems as offering some valuable lessons for other developing countries.¹⁴

At the same time, health problems usually associated with affluence are on the rise, including chronic diseases related to a more sedentary lifestyle and a diet increasingly heavy in fat, sugar and refined foods, as well as smoking and excessive alcohol consumption.¹⁵ Related non-communicable diseases, and in particular lung cancer, obesity and diabetes, are increasing, and the World Bank has predicted that if they are not addressed, China could see a

fall in life expectancy: the average span of healthy life, at 66 years, is already proportionally lower than in many other countries.¹⁶ In terms of international experience, there is a good deal that China can learn from the rich countries in terms of treating these diseases, but the record on prevention is less impressive, probably because tackling the drivers of these diseases requires measures that go far beyond the health sector.¹⁷ If China follows the path of other countries, it is likely that these “diseases of the rich” (*fuyubing* 富裕病) will come to be over-represented among the poor, and that they will place a severe burden on the health system.¹⁸ However, because their immediate drivers lie in personal behaviour, they have not generally become a source of social conflict.

It is the third cluster of problems – “diseases of transition” related to rapid industrialization and urbanization – with which this special symposium is largely concerned; and, in particular, health risks related to air, water and soil pollution.¹⁹ Although industrial accidents cause health emergencies, pollution more often leads to delayed but long lasting health effects owing to the gradual accumulation in the environment and the human body of toxic levels of chemicals, frequently from multiple sources. Pollution-related health impacts are rooted in complex interactions between economic, political and social factors, and therefore they require a multi-faceted governance response that presents a significant new challenge for policy.²⁰ They also often entail conflicts of interest and contestation over responsibility,²¹ and so are more likely than many other health issues to lead to social tensions and conflict. While these problems persist in rich nations to varying degrees, as a result of its extremely rapid economic growth over the reform period, China is encountering them in an unprecedentedly compressed and acute form, and the experience of the earlier industrializers is of only limited referential value.²²

In its Environment and Health Work Plan for the 12th Five-Year Plan, the Ministry of Environmental Protection (MEP) describes the situation with regard to the health impacts of pollution as “grim” (*xingshi yanjun* 形势严峻):

First, complex pollution is serious and widespread, and the population exposed is large; second, the period of exposure is long, exposure levels are high, and it will be difficult to eliminate the health impacts of historically accumulated pollution in a short period of time; third, there is a distinct difference between urban and rural areas, with air pollution the main environment and health problem in our nation’s cities, while water and soil pollution are the main problems in rural areas; and fourth, at the same time that traditional environment and health problems caused by inadequate basic sanitation facilities have not been entirely dealt with, risks stemming from rapid industrialization and urbanization are gradually increasing ... it will be hard to resolve these four problems within a short period of time, and in the future, health risks from environmental pollution will gradually increase, presenting a serious situation for environment and health work.²³

Attention has been drawn to the problem of pollution’s impacts on health both by standard indicators and by “focusing events.”²⁴ Cause of death statistics show that cancer is now the leading cause of death in rural as well as urban areas, and that other non-communicable diseases associated with environmental factors account for a growing percentage of the burden of disease.²⁵ Pollution-related health problems are increasingly the cause of complaints, lawsuits and mass protests.²⁶ According to MEP statistics, 56 of the 232 relatively large (grade III and above²⁷) environmental incidents that occurred between 2007–11 involved cases in which environmental pollution caused damage to health, and 19 of 37 “mass incidents” were triggered by environmental impacts on health. As the MEP remarks, these incidents “caused a serious threat to the health of the masses and to social stability, and had a very negative impact (*elie de yingxiang* 恶劣的影响), both domestically and abroad.”²⁸ Over the last few years, a steady flow of media reports on crises over tainted milk powder, cadmium rice and, more recently, lead poisoning in children, have drawn growing public

attention to slower burning but worrying problems of exposure to dangerous levels of chemicals through the food supply.²⁹

What Do We Know and How Do We Know It? Data on Pollution and Health

One of the main challenges when working on pollution and health in China is that there is insufficient data to support a comprehensive analysis of the problem. While relatively good information on infectious diseases and lifestyle-related risk factors is available from the Centre for Disease Control (CDC) disease surveillance system and from nutrition surveys, an adequate assessment of the health impacts of pollution remains elusive, and efforts to make such assessments and to estimate their costs have generally used limited data or proxy variables.³⁰ The first environmental pollution census was conducted in 2007. It provided more information on the extent of industrial pollution and drew attention to the growing importance of pollution from agriculture and animal husbandry, and from liquid and solid household waste.³¹ However, the health implications were not discussed and the full findings were not made public. The MEP Work Plan summarizes the challenge of data as follows:

no nationwide or large regional investigations into environment and health have been conducted in our nation ...there is no clear baseline information about the geographic distribution of the health impacts of environmental pollution, about the extent of damage to health, or about the evolution of trends. This not only makes it difficult to distinguish the most hazardous environmental factors, and propose effective measures for responding, but also to conduct an assessment of health risks related to environmental pollution, make timely adjustments to policy, and propose targeted measures for dealing with [problems].³²

As a result, both the government and the public are still struggling to assess the scale and distribution of pollution-related health problems from regular environmental and health monitoring data and a limited number of special investigations and local studies.³³ More comprehensive data on both air and water quality is available for urban areas and as a result there has been more analysis of their health effects, as well as estimates of their economic costs.³⁴ Data on rural areas is much spottier.³⁵ Much of the RMB2.53 billion that the MEP requested for environment and health work under the 12th Five Year Plan is for risk assessment surveys and special investigations (*zhuanxiang diaocha* 专项调查), with additional funds in the larger ministry and national science foundation budgets.³⁶ However, given the size and heterogeneity of China, and the weakness of monitoring systems, it is unlikely that the picture will ever be complete, or, despite a trend towards greater transparency, that all the data that is collected will be made public in the near future.³⁷

In this context, media and NGO reports play a key role in shaping public perceptions of the scale and nature of environment and health problems. Studies of environmental awareness and complaints have found that media reports are by far the main origin of public information³⁸ and that they are also an important source of information for the government. When selecting sites for cancer control and prevention work, the CDC included not only places that showed higher than usual rates of cancer in the cause-of-death data, but also sites that were reported in the media as “cancer villages.”³⁹ This is probably partly because the CDC Disease Surveillance Points (DSPs) were selected on the basis of standard demographic indicators and so do not capture the health effects of geographical concentrations of polluting industry.⁴⁰ In addition to providing information about potential actual hotspots of disease, media reports also flag places and populations where public perceptions of disease, sometimes in combination with other factors, are creating social conflict and generating demands to which the government feels it must respond.

Policy Initiatives and Policy Research

Addressing the impacts of pollution on health will present a serious policy challenge for the Chinese government in coming years. It requires not just greater investment of resources in existing institutions and activities in order to implement current policies more effectively, but also the adoption of new tasks and responsibilities within individual agencies and the forging of new collaborations across them. At a minimum, it calls for an adjustment of priorities within the health and environmental policy streams to reflect the new demands of the problem. Until recently, environmental protection policies emphasized only the reduction of aggregate emissions of pollutants (*zongliang kongzhi* 总量控制). While progressively stricter controls are achieving some success in this⁴¹ and will have long-term benefits, addressing health risks directly requires prioritizing the control of pollutants particularly damaging to health and identifying populations that are especially vulnerable.⁴² China's size and diversity mean that a more locally tailored approach to environmental protection will be needed. In many places, greater attention will have to be paid to the notoriously difficult problem of regulating small industries which, while relatively unimportant in terms of their contribution to overall emissions, are particularly damaging in their health effects (a phenomenon Su Yang refers to as "small pollution, great harm" (*xiaowu dahai* 小污大害)).⁴³

For the health sector, addressing pollution's impact on health implies a greater focus on monitoring and responding to pollution-related diseases. In some cases, this could build on current CDC disease surveillance. For example, the monitoring of maternal and child health might begin to include monitoring the exposure of women of child-bearing age to chemicals that can affect fertility and the health of the foetus, and the exposure of children to heavy metals that can affect their health and mental development. When training health workers and considering investment in health facilities, it would be helpful to assess shifts in local needs that are likely to result not only from changes in demography and living standards generally used in predicting needs for health personnel, but also from local patterns of development that are likely to generate specific health risks.⁴⁴ The relationship between industrialization, environmental change and health impacts raises the larger question of how applicable are models of the epidemiological transition and provisions for healthcare that have been developed largely in the context of early industrializing countries to nations experiencing much more rapid and intensive processes of industrialization.⁴⁵

This kind of targeted enforcement and preventive approach to healthcare provision can only be successful with the active involvement not only of the health and environment agencies, but also other ministries, in particular those with responsibilities for land use and development planning.⁴⁶ This would be essential in order to identify and anticipate changes in the nature and trends of pollution-related health risks, and to ensure a more integrated approach to regional and local development planning. Otherwise, as many studies have shown, enforcement efforts are often undermined by the loss of individual and collective income that accompanies campaign-style environmental management.⁴⁷ This kind of integrated planning needs to be conducted on a local as well as a national level if it is to be responsive to the rapidly changing situation in different cities and rural areas. It also needs to take into consideration differences in governance capacity.⁴⁸

Policy in China is already moving forward on some of these fronts. The emergence of pollution-related health issues as a somewhat separate problem field has been accompanied by efforts to establish a related policy stream to deal with them.⁴⁹ Although progress has been halting and uneven across and within sectors and levels of government, a shift is evident in a marked change in terminology. While environmental health problems related to poverty are usually referred to by the term, "environmental hygiene" (*huanjing weisheng* 环境卫生), the term, "environment and health" (*huanjing yu jiankang* 环境与健康), explicitly includes

health problems related to pollution. It is interesting that, while this new language echoes World Health Organization (WHO) terminology, its use in China has been spearheaded by the MEP rather than the Ministry of Health (MOH).⁵⁰

A major landmark was the release, in 2007, of the National Action Plan for Environment and Health 2007–15, which was signed by 18 ministries.⁵¹ This enabled a preliminary review of the state of knowledge on environment and health and of existing management capacity in a number of sample counties. It also provided for the establishment of a coordinating mechanism with parallel offices in the MOH and MEP to provide an organizational structure for environment and health work. The new Environment and Health Work Plan for 2011–15 steps up the investment with a request for RMB2.53 billion for research and (mostly central-level) capacity building for environment and health work.⁵² The focus is on integrated monitoring and risk assessment in key regions, the development of standards and legal statutes, and public education. Acknowledging that inter-agency collaboration has been limited to date, the plan calls for a more integrated approach to environment and health work. However, it remains limited in that it only specifically mentions initiatives within the MEP and the MOH, and makes no reference to collaboration with agencies responsible for land use and development planning.⁵³

However, a new concern with environmental health risks is also evident in broader policy. The Outline of the 12th Five Year Plan for National Economic and Social Development refers explicitly not just to public demand for environmental goods in general, but also to the threat that pollution presents to health and to social stability.⁵⁴ The MEP's overall programme for the 12th Five-Year Plan period also includes detailed location and sector specific goals for the control and remediation of pollution, which are clearly influenced by an increasing concern with impacts on public health.⁵⁵ Control of heavy metal pollution also received special attention in the State Council's first specific 12th Five-Year Plan for the Comprehensive Control of Heavy Metal Pollution (*zhongjinshuwuran zonghefangzhi* 重金属污染综合防治), which stipulates target regions and industries.⁵⁶ Other initiatives are to be found in the programme for Comprehensive Control of the Rural Environment (*nongcunhuanjing zonghe zhengzhi* 农村环境综合整治),⁵⁷ and in the plans of the Land Resources, Agriculture and Transport ministries.⁵⁸ Many of these plans remain on a general level, but it is nonetheless clear that a concern for the health impacts of pollution has moved quite quickly up the agenda.

A number of departments within the CDC work on environment and health issues, and the agency has taken a leading role in the landmark Huai River Basin cancer study as well as broader cancer prevention initiatives. However, the MOH has been less active than the MEP and it seems that pollution-related health problems remain quite marginal to its work.⁵⁹ The detailed plan for health sector work in the 12th Five Year Plan period has yet to be released, but it appears that the new focus will be on bringing non-communicable diseases under control by focusing on lifestyle and individual behaviour, including reducing smoking and drinking, improving diets and increasing physical activity.⁶⁰ Although environmental impacts on health are quite prominent in the science and technology development plan for the health sector,⁶¹ so far there is no indication that the MOH will produce a work plan and a request for resources for environment and health work similar to that published by the MEP. In fact, perhaps partly because existing targets for health still focus on diseases related to poverty, and partly because there is less international experience to draw on, it seems that the health system may be “hopping over” the diseases of the transition to focus on the diseases of affluence.⁶² It is telling that the MOH has postponed the convening of the “Forum on Environment and Health” that it hosts alternately with the MEP as part of the National Action Plan.

As in many other policy fields, implementation at the local level lags far behind the goals set at the centre: as of 2009, only two provinces had an action plan for environment and health.⁶³ Although it is more active than the MOH at the national level, the MEP's limited resources and autonomy make it hard for it to take the lead on environment and health work at the local level, especially in rural areas. In contrast, the CDC has a stronger local presence owing to heavy investment in disease monitoring and control in recent years in response to SARS and avian flu. However, rural health work continues to focus on sanitation and infectious diseases, and also more recently on initiatives on individual behaviours associated with chronic diseases, such as diabetes and hypertension. Although special projects have been introduced in certain disease hotspots, and local CDCs have sometimes taken the lead in drawing attention to problems, no regular funding is available to identify and treat pollution-related health problems.⁶⁴ As recent reports and articles on lead poisoning in children show, most local CDCs seem completely unprepared to deal effectively with pollution-related health crises.⁶⁵ Even if they recognize the problem, the fact that nearly all their funding is tied to the performance of tasks mandated by the centre leaves little room for local CDCs to pursue other priorities, unless money can be raised independently through the sale of drugs and medical services.

As a result, despite the significant investments in controlling aggregate emissions and improving rural healthcare facilities over the last decade, the MEP work plan acknowledges that these efforts have not “landed effectively” (*luoshi* 落实) on the problem of pollution-related impacts on health and, if anything, public discontent is on the rise.⁶⁶ In many areas, policy and provision appears to be seriously out of step with local needs and there is a misalignment of resources and personnel. Su Yang describes the situation at the local level as suffering from “three basic absences” (*sange jibenmeiyou* 三个基本没有) in terms of coordinating mechanisms; the specification of responsibility for managing; and the allocation of funds for environment and health work.⁶⁷ In fact, some policies designed to address traditional *huanjing weisheng* problems may unintentionally exacerbate health risks from pollution, for example when the provision of piped drinking water leads to the neglect of longer term problems resulting from the pollution of irrigation water and soil.⁶⁸

The barriers to more integrated and locally appropriate policies should not be underestimated and are, to a large degree, structural. In addition to generic aspects of China's governance system (which is characterized by well-documented problems of fragmentation and gaps in implementation), this issue presents particular challenges. As a cross-cutting policy area that is the partial responsibility of many agencies but the central responsibility of none, environment and health has been termed an “institutional orphan,” and the OECD has noted that it ends up neglected in almost every policy system.⁶⁹ Add to this the rapidly changing distribution of drivers, risks and health impacts across space and populations as the result of China's rapid industrialization and urbanization, and the long latency period of many environmental impacts on health, and it is not surprising that policy, institutional and human capacity-building lag far behind needs on the ground. At the same time, traditions of local experimentation and learning⁷⁰ offer hope that well-designed case studies can inform a better understanding of local needs and the development of more responsive policy.

All this presents fertile ground for social science research, including analysis of the way in which policy evolves in response to new problems; the interactions within and between ministries; the ways in which different types of knowledge and institutional interests combine to shape the framing of issues; the lessons that are drawn from reference to different international experiences; and the negotiation of roles, resources and responsibilities over central and local scales. Yet, research on environment and health policy is still quite minimal, as can be seen from the general lack of mention of policy and institutional arrangements in the papers in this collection. Most of what we know about these matters comes not from

academic research but from government agency reports and programme evaluations (particularly those by Su Yang of the State Council's Development Research Centre),⁷¹ and a limited number of international organization reports.⁷²

As was the case three years ago, academic research on policy remains largely segregated within the environmental and health sectors, with little intersection between the two. Although understanding of matters such as local variation in the implementation of pollution control policies, the factors influencing the behaviour of various actors within the MEP, and the amount and quality of publicly available information about emissions has deepened considerably over the last few years, little of this work has touched directly on pollution's impact on population health.⁷³ Meanwhile, studies on health continue to focus on access to and financing of healthcare, with new streams of work developing on the resurgence of infectious and parasitic diseases, such as tuberculosis and schistosomiasis, and on emerging diseases, including zoonoses.⁷⁴ It is notable that the World Bank's recent report on non-communicable diseases mirrors the MOH's concern with lifestyle-related drivers of disease and largely ignores pollution.⁷⁵ Since Fang Jing and Gerry Bloom's 2010 article, there has not been any further systematic analysis of the health system's response to the problems of pollution.⁷⁶

Another challenge for research continues to be linking the broader picture of China's development and poverty alleviation strategies to their implications for environment and health. In principle, everyone recognizes that the roots of pollution-related health problems lie in economic development strategies, and that TVEs and other small scale rural industries in particular present a tension between opportunities for individual and collective income and employment and potential risks to health.⁷⁷ Although a number of excellent books have considered the environmental impacts of development and its implications for sustainability and continued growth,⁷⁸ there has been little detailed work on the complex interactions between development, environmental quality and human health, particularly as they relate to industrialization.⁷⁹ In determining how the location and regulation of industry can be better managed in order to reduce people's exposure to pollution, a better understanding is needed of the role of ministries outside of health and environment, including the National Development and Reform Commission and the ministries of Land and Agriculture. The same can be said of the policies, including Main Function Area Planning (*zhutigongnengqu guihua* 主体功能区规划), that play a role in shaping regional development strategies. This is especially true at a time when both market incentives and regional planning policies are encouraging the relocation of industry to hinterland areas.⁸⁰

Public Responses and Related Research

As the articles in this special section show, research on public responses to environmental impacts on health has made more progress than work on policy. In addition to the segregation of relevant research fields discussed above, this may also reflect what Perry and Heilmann see as a broader neglect of policy studies in recent years, driven by the greater ease of access to non-elites as well as widespread interest in whether market reform and rising incomes are leading to demands for greater freedom of information and participation.⁸¹ Certainly, the social conflict generated by pollution's impacts on health has attracted the attention of social scientists interested in civil society, environmental movements, and social movements more generally, and this has had implications for the kinds of topics that have been researched. These fall into two broad categories. The first relates to awareness, and asks to what degree are Chinese citizens able to assess the extent of the risk that pollution presents to their health, and where does their information come from. The second category relates to how people respond to the health risks they perceive, including their use of formal and informal

mechanisms for expressing grievances and making demands, and their efforts to protect themselves from harm. Quite a few studies consider the variables that mediate between perceptions and action.

This research has shown that the Chinese public, including rural residents with limited formal education, often have quite a sophisticated understanding both of the ways in which pollution can affect health and of the uncertainty regarding causality. They make use of various “lay epidemiologies” to try to identify the environmental origins of what they perceive as being unusual clusters of disease.⁸² Where pollution is easily detectable, public awareness of health risks appears to be quite high and understanding of cause–effect relationships may be quite nuanced. At the same time, villagers (and, indeed, urban residents and researchers) are much less aware of pollution sources that are hard to detect with the senses, and they are more ready to blame local than distant sources.⁸³ Other studies show that, particularly in the case of invisible pollutants (including heavy metals), people’s knowledge of exposure pathways is limited, with most suspecting drinking water but fewer understanding the risks of contamination through food, which are particularly complex given the propensity of different plants and animals to concentrate toxins to different degrees.⁸⁴

In terms of the relationship between awareness and action, our knowledge has also increased significantly, to the point that we have a good comprehension of the factors which mediate between the two. Findings from recent research in China echo those of studies in other industrializing countries, and highlight the lack of any inevitable connection. People often live with pollution for many years out of a calculus that includes the degree of severity and the type of effect (immediate or chronic, and whether it affects the ability to work, bear children, etc.).⁸⁵ In cases where effects are slow to manifest themselves, people often become habituated to a polluted environment, and uncertainty about causality exacerbates the tendency to inaction, although sudden changes or events can prompt a rapid shift in perception.⁸⁶ Economic considerations, including whether the polluter provides a source of employment or income from compensation, as well as the availability of alternative sources of livelihoods or the possibility of migration, may also shape whether or not citizens protest against pollution.⁸⁷ Human and social capital also affect responses, with studies finding a clear relationship between literacy and complaints, even when income is similar⁸⁸ and that social networks can serve both to heighten and suppress conflict over pollution. There is often no neat separation between polluters and victims, and people downplay or are more willing to tolerate pollution if they are causing it themselves or if the perpetrators are perceived as “locals” rather than “outsiders.”⁸⁹ The presence of local elites who are able to serve as intermediaries with local government and/or the media can also be an important factor in whether and how grievances are voiced.⁹⁰

As the articles in this collection by Johnson, and Deng and Yang illustrate, pollution issues have particular political opportunity structures that involve complex sets of institutions and policies at both the local and national level.⁹¹ Astute citizens and NGOs frame their claims in order to maximize the likelihood of a favourable outcome. This often entails “piggybacking” on other issues, such as land rights or damage to crops, that are receiving greater attention from the government, for which evidence is easier to gather, or which are less sensitive.⁹² The tendency for residents to demand the provision of piped drinking water similarly reflects a demand for a public good that can be provided fairly easily, and which is desirable for other reasons.⁹³ When pollution’s impacts on health are seen as a viable frame, they in turn may be used as a vehicle for pushing for change on broader issues of transparency or greater public participation.⁹⁴ Whether or not demands are made and met, citizens routinely pursue a number of strategies for reducing their individual exposure to pollution, including changing their sources of food and drinking water, or moving away.⁹⁵

Although a good deal of work has now been done on public perceptions of, and responses to, pollution's impacts on health, the scope remains somewhat limited. Largely because of their interest in social movements, many researchers have worked on situations which involve obvious pollution and/or health problems that have generated, or have the potential to generate, conflict. As a result, while these case studies are revealing about the processes discussed above, they are a rather selective part of the landscape of public perception and responses. This is even more the case with studies that examine the perception and framing of these issues in the context of microblogs and online communications. Although these present valuable and easily accessible new sources of information on public attitudes,⁹⁶ analysis of this material in the absence of interviews or participant observation among relevant segments of the public raises questions about how online expression relates to offline expression and behaviour.

Much of this research refers in passing to the development of environmental justice movements in the United States and Europe, and cites related literature. However, to date, there is not much systematic analysis of how far the parallels go. In the early industrializing countries, growing awareness of the impacts of pollution on health was an important factor in the development of these movements. This included both the discovery of clusters of disease in particular communities and the disproportionate burden of environmental harm on disadvantaged populations, as well as a growing awareness that the middle class and rich were also being exposed, albeit at lower levels, through air, drinking water and food.⁹⁷

There has been little careful examination of how environmental health burdens map onto patterns of social stratification in the Chinese context. Although migration complicates the picture, there is a clear correlation between poverty and traditional environmental health problems, including endemic and certain infectious diseases, as well as child and maternal health status.⁹⁸ But, although there is a tendency to assume that the burden of pollution-related health risks also falls disproportionately on the poor, its distribution across population groups in China remains an empirical question. Those with less financial, human and social capital have fewer choices in terms of their work and living arrangements, and in China this means that rural populations, migrants, farmers who have lost their land (*shidi nongmin* 失地农民), and low income urbanites are generally more likely to be vulnerable to health risks of all kinds and to have less access to medical care.

However, in the case of pollution-related health risks, it seems that complex interactions between natural and human resources, development trajectories (including linkages to regional and global markets), governance capacity and political significance play out very differently in different locations.⁹⁹ As a result, rather than the poorest places, some of which remain relatively free of industry and have quite low levels of urbanization, it may be that (as on the global scale¹⁰⁰) the greatest health risks from pollution are concentrated in lower to middle income and transitional areas, where agricultural and industrial activities intermingle, and infrastructure, institutional and governance capacity are weak. These are primarily peri-urban districts, smaller cities and industrializing rural areas.¹⁰¹ Within these contexts, social inequalities and power relations would obviously play a role in the distribution of environmental burdens and benefits. For example, some research shows that rural-urban migrants are more likely to be exposed to pollution than residents of the same county who have urban residence, even after controlling for occupation.¹⁰² Other studies suggest that the fault lines are not constant, and that the tangled relationship between polluters and the exposed that exists in many places in China defies a simple environmental justice analysis. The distribution of risks is further complicated when farmers in contaminated areas sell their crops and buy in food from other areas, "democratizing risk."¹⁰³ These complicated interactions await more systematic analysis.

Research conducted so far also raises questions about environmental justice processes, including which pollution and health problems come to the fore, and how they are framed and by whom. Clearly, the media is influential in shaping both public and researchers' perceptions of pollution-related health problems, and although there has been no new quantitative analysis since Yang Guobin's 2010 article, it seems that it is no longer quite the case that the media focuses on urban issues and neglects the impact of industrial pollution in rural areas. This may be partly because the government has acknowledged the problem of rural pollution in official documents, thereby opening the topic up for media reporting, but it is also because the connection between rural pollution and food safety is becoming clearer and so increases the interest of such stories to urban readers and audiences. At the same time, media attention is drawn to certain problems and not others, with a preference for crisis situations and "dread risks" like cancer over less dramatic problems.¹⁰⁴ This contributes, as it does in other countries, to the tendency for these risks to loom particularly large in the minds of the public. It most likely also results in certain places and populations gaining attention at the expense of others that may be experiencing equally or more serious problems. To the extent that media reports prompt a response from government, it seems likely that this phenomenon, known as "children who can cry get milk" (*huikude haizi you naichi* 会哭的孩子有奶吃), may be more serious in China, given the absence of reliable public information and mechanisms for participation in decision making.¹⁰⁵

Although most of the research to date focuses on citizens as individuals or in informal groups, the space for civil society organizations to work on pollution and health has increased considerably over the last few years, and a number have begun to do so, mostly with funding from international donors. These include the Friends of Nature, Greenpeace, the Institute for Public and Environmental Affairs (IPE), and the Centre for Legal Assistance to Pollution Victims, as well as a number of smaller organizations working at the provincial and local level. Their efforts have included publishing reports on pollution's impacts on health, pursuing accountability regarding public information about pollution (most notably in recent months, small particle air pollution), representing citizens in court cases, and reporting violating enterprises to the MEP or media.¹⁰⁶ Despite the many constraints on NGOs in China, this issue area has opened up considerably, with the central MEP acknowledging the limits of its capacity to monitor pollution, especially in rural areas, and welcoming the participation of NGOs in enforcement.¹⁰⁷ This also represents something of a shift from the situation Yang Guobin described in his 2010 article, in which he found that NGOs still focused primarily on non-contentious topics of concern to urban residents.¹⁰⁸

However, it is unclear to what extent NGOs are actually able to take on a larger role, given their own limited manpower and technical expertise, and the fact that local governments (and, indeed, sometimes local populations) are often much less enthusiastic than the central authorities about their acting as watchdogs. NGOs are also faced with a choice between attempting to seek redress for health impacts experienced by particular communities where the evidence to adequately prove cause and effect is often lacking, and working more generally to raise awareness with a view to promoting more far reaching policy change. Strategies can also emphasize scientific or experiential knowledge.¹⁰⁹ It seems likely that the lack of public and reliable data in China, the different pathways through which NGOs have come to work on these issues, and the various collaborative relationships they have with international NGOs of different stripes, will lead them to develop strategies that mix local and international frames and tactics. There remains a great deal to be researched here in terms of the changing and increasingly complex flows of information, issue formation, and mechanisms for interest aggregation and representation regarding pollution and health. Research on the interaction between NGOs and industry also remains largely a blank slate, although this is a significant part of the work of the IPE and Greenpeace. Given that the

impact of pollution on health presents a moral as well as an economic issue in terms of the relationship between industry and affected populations, it seems important to investigate how such claims are made and how different industries respond.¹¹⁰

Interdisciplinary and International Collaboration

In the course of this review, I have mentioned a number of specific gaps in research regarding policy and civil society. This section discusses some broader challenges involved in developing this field of research, and flags the need for more systematic collaborations.

There is a substantial body of international literature on how environmental factors affect health and the challenges this presents for policy. However, much of this literature was written in the context either of traditional, poverty-related environment and health problems, or those that are currently experienced in industrialized countries.¹¹¹ The compressed and intense impact of environmental degradation on health, coupled with uneven economic growth, and the diversity of the natural environment, development pathways and governance capacity, means that neither of these approaches adequately captures the processes that are unfolding in China. So far, there has been no systematic analysis of how these frameworks might be adapted in order to take into consideration China's unique development pathway and state-society relations. If researchers are to avoid attributing to China's particularities phenomena that are in fact generic to the problem or common to other countries, and better understand the interaction between various factors, this analysis would ideally involve cross-national comparison and collaboration.¹¹²

Unfortunately, most international collaborations in this area are still structured as partnerships between researchers from developed countries and China. This is often a requirement of bilateral funding agencies, which understandably wish to support their own national institutions and often also have a more or less explicit advocacy goal, particularly in research programmes that relate to the environment or to civil society. It also reflects the networks of researchers. But, although there are common challenges (such as dealing with air pollution in urban areas), many of China's environment and health problems do not map neatly onto those of the early industrializers. For example, the rapid and largely unregulated industrialization of rural areas, which is the source of many of the most serious health threats in China, is an experience unfamiliar to the US or Europe, where industry was generally more concentrated around urban centres.¹¹³ Many collaborative projects between international and Chinese NGOs suffer from a similar difficulty in matching developed country experience to China's current needs.¹¹⁴

More comparison of China with the other BRICS nations undergoing similar processes of rapid industrialization would give a better understanding of the nature and drivers of environmental health risks in these contexts. Such comparisons would also help when unpacking the roles of various state and civil society actors; when considering how these problems can be more effectively addressed in transitional societies with regional diversity and limited capacity and resources; and when examining tensions between different development goals. For example, India also has serious problems with heavy metal pollution (much of it also from small-scale industries in rural and peri-urban areas), overuse of fertilizers and pesticides, waste products from livestock rearing, illegal additives in food, etc. India also faces many of the same challenges as China in addressing pollution-related health risks, including fragmented authority, inadequate data, an underdeveloped regulatory system, lack of trained personnel, and serious corruption.

At the same time, the media, NGOs and individual citizens in India have freedom of speech, and politicians are subject to democratic processes that should bring greater accountability. To the extent that data is available, it is in principle accessible to the public.¹¹⁵

However, it seems that greater freedom of information and public participation in India have resulted neither in the chaos (*luan* 亂) feared by the Chinese government, nor in a more concerted effort by the government to address pollution-related health problems. If anything, the fear of instability seems to be driving a more urgent response on the part of the Chinese government through a combination of tactics that have also been observed in the handling of discontent among laid-off State-Owned Enterprise (SOE) and migrant workers, and in disputes over land. Short-term reactions include repression or, increasingly, financially compensating or otherwise placating protestors; but in many cases, conflict also triggers government efforts to develop policies to address, or at least manage, the problem in a more long-term way. An examination of this apparently paradoxical situation would shed some interesting light on the workings of state–society relations in both China and India.

For researchers whose focus remains within China, the field would benefit from a more careful selection of sites and samples for social science research, and more structured comparison between regions and localities. Quantitative studies will continue to be hampered by the lack or unavailability of data, but a good deal more could be done with the data that does exist,¹¹⁶ and particularly by linking environment and health data with data on the regional distribution of industry. This would entail more collaboration with economists, geographers and other researchers who work on regional development, and with environmental and medical scientists who study the health impacts of pollution. These linkages would not only improve our understanding of the environment–health–development nexus, but also increase the relevance and impact of research by helping to mainstream a concern with environment and health into the development agencies to which researchers in those fields are connected. Collaboration across the natural/social science boundary is also welcomed by environmental scientists and epidemiologists, who are often frustrated that their work ends with a description of the problem and, at most, a formulaic set of recommendations for policy.

A better understanding of interactions between local development pathways, environment and health would make possible more focused case studies of institutional development, policy implementation and state–society interactions. So far, social scientists studying pollution and health have tended to work in sites they already know, or which have attracted media attention. This approach has produced some valuable results in a relatively short space of time. But, if case studies are going to contribute to knowledge that can support more effective responses to pollution-related health problems, the selection of future sites needs to target particular types of problem or governance issues more deliberately. In essence, this calls for the engagement of a greater range of disciplines in environment and health work and more interaction among them.

Interdisciplinary research on environment and health is increasingly supported, in principle at least, by a number of private foundations and national funding agencies,¹¹⁷ but it continues to be at least as difficult as it is necessary. Even within the social sciences, differences in epistemological and methodological approaches within and across disciplines make communication hard, and sustained collaboration even harder. Not surprisingly, these problems present a still greater barrier when it comes to collaboration between the natural and social sciences. Disciplinary training has a tendency to encourage natural and medical scientists to emphasize methodological or technical virtuosity, while social scientists invest heavily in the development of highly nuanced conceptual or theoretical frameworks. Neither of these is much appreciated by colleagues in other fields, or by potential users of knowledge outside academia.¹¹⁸

Although disciplinary training necessitates the development of insider cultures and language, researchers who wish to work in interdisciplinary fields need to cultivate the ability to advance disciplinary knowledge while also communicating effectively with those in other

fields in order that mutual learning can take place. This does not mean that we should all strive to become polymaths, or even that many social scientists will engage in full-blown interdisciplinary collaboration, which is expensive and time consuming. However, we do need to be able to assess better how the kind of knowledge our discipline generates relates to that of others and how our work can be mutually informative.¹¹⁹ This is especially important if social scientists wish their work to be taken seriously by non-academic users of research. The experiences of the EcoHealth Network and of the Forum on Health, Environment and Development suggest that a network approach that emphasizes cumulative learning is probably the most feasible way to foster productive interdisciplinary interaction and incubate collaborations. As the field develops, interdisciplinary networks will probably need to be forged around more specific issues.¹²⁰

Conclusion: Looking to the Future

The problem of the health effects of industrial pollution is one that China will have to grapple with for decades to come. Although environmental regulation has become progressively stricter over the last 15 years, much of China's land and many of its rivers systems are already polluted, and without serious remediation cannot be safely used for the production of food or for drinking water.¹²¹ At the same time, although the share of industry in China's GDP is now falling overall, the search for lower land and labour costs, and the policy of promoting more balanced regional development, are now encouraging the movement of industry into the hinterland and west.¹²² In many ways, these processes of regional development within China mirror relations between developed and developing countries at the global level, and policy is complicated by similar dilemmas because the central government cannot ask that poor areas forgo the benefits of economic growth enjoyed already by residents of coastal regions. These trends are likely to produce new patterns of pollution-related health problems and related social tensions, especially because public demand for environmental quality is rising faster than environmental management capacity.¹²³ Although major function area planning defines areas for limited development and conservation, it is far from being operational on the local level that would be needed to avoid pollution being transferred along with industry. In fact, the specification of new areas for priority development (*zhongdian kaifa* 重点开发) will probably aggravate the situation in some places.¹²⁴

At the same time, even with improved regulation, the latent health effects of cumulative previous exposure will continue to manifest themselves in earlier industrializing areas for years to come, creating challenges for healthcare provision and social stability.¹²⁵ In many cases, the polluting industries will have moved or closed, and so the problem is likely to shift towards determining responsibility for the costs of healthcare and lost earning capacity, as well as cleaning up soil and water pollution. Establishing causality and attributing responsibility will be impossible in many cases, and the costs of remediation will probably fall on the government. Although the MEP is researching options for some kind of Superfund programme, and a number of impressive ecological restoration projects have been conducted, these initiatives demonstrate that the comprehensive remediation of existing polluted sites would be staggeringly expensive.¹²⁶ In the case of land that is under cultivation, it would also involve providing alternative livelihoods and food sources for affected populations.

In the words of the MEP, the situation regarding pollution and health in China seems grim, but there are some positive forces at work. By relocating or outsourcing many of their polluting or extractive industries to China and other developing countries, the early industrializers (Japan, Taiwan and Korea, as well as Europe and the USA) were able to externalize many environmental costs. Although China is increasingly investing in

agricultural production in other countries, both market factors and development policies mean that industry continues to relocate largely within national borders. If pollution is not controlled, its health effects will fall upon Chinese people and the government or private citizens will have to bear the financial burden. In this sense, as in other policy areas in which the externalization of costs is relevant, “China has no China.”¹²⁷ As a result, both humanitarian and financial concerns provide strong incentives to address problems head-on which other nations have had the luxury of displacing or deferring. For the government, these motivations are further bolstered by concerns about social stability and legitimacy. All this, as well as the expanding room for public participation in this issue area, offers hope that the political commitment to address pollution’s effects on health will continue to gather momentum and resources. As this process unfolds, social scientists have the opportunity to make a contribution to understanding and addressing one of the most urgent problems facing China today.

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¹ Holdaway 2010a.

² World Bank and State Environmental Protection Agency (SEPA) 2007; WHO and UN Development Programme 2001.

³ World Bank and SEPA 2007; OECD 2006; WHO 2005; CCICED 2008; Matus et al. 2011; Ho, Mun and Nielsen 2007. For an analysis of media reporting, see Yang, Guobin 2010.

⁴ Kingdon 2010.

⁵ Given the limitations of space and the wide range of literature discussed, this review cannot hope to be comprehensive; instead it seeks to point to key trends with a view to identifying opportunities for the further development of this fairly new field of research. As far as possible, I have limited citations to research findings published since the previous review.

⁶ For further detail and a range of framings of these relationships, see Briggs 2008; Corvalán, Kjellström and Smith 1999; Caincross et al. 2003; Forget and Lebel 2001; UNEP 2009. The latter provides a good evaluation of several of the earlier frameworks.

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- ⁷ OECD 2007; Listorti and Doumani 1996.
- ⁸ See unep.org/ieacp/health 2009; Smith and Ezzati 2005.
- ⁹ Zhang, Junfeng et al. 2010; Wang, Wuyi et al. 2010. For a more in-depth discussion of interactions between migration, environment and health, see Holdaway 2012a; Chen, Chen and Landry 2012; Ma 2010; Schoolman and Ma 2012.
- ¹⁰ World Bank 2011.
- ¹¹ Zhang, Junfeng et al. 2010; Fang, Pengqian et al. 2010; UN Development Programme 2007; World Bank 2007.
- ¹² Ministry of Foreign Affairs/UN System in China 2010.
- ¹³ Zhang, Junfeng et al. 2010; see also Smith and Ezzati 2005; Corvalán, Kjellström and Smith 1999.
- ¹⁴ Wang, Xiaolin 2010.
- ¹⁵ van de Poel, O'Donnell and van Doorslaer 2012; Wang, Wuyi et al. 2010.
- ¹⁶ Wang, Marquez and Langenbrunner 2011.
- ¹⁷ Wilkinson and Marmot 2003; Wilkinson 2005; Prüss-Üstün and Corvalán 2006.
- ¹⁸ Wang, Marquez and Langenbrunner 2011.
- ¹⁹ Occupational diseases are another important category of risks related to urbanization and industrialization, but are not discussed here due to constraints of space.
- ²⁰ Zhang, Junfeng et al. 2010; Wang, Wuyi et al. 2010; OECD 2007
- ²¹ Brown 2007.
- ²² Holdaway 2012b; Su and Duan 2010.
- ²³ MEP 2011a. Author's translation.
- ²⁴ Kingdon 2010.
- ²⁵ MOH 2012.
- ²⁶ van Rooij 2011, 193–219; Dong et al. 2011.
- ²⁷ According to the MEP "Reporting methods for sudden environmental incidents," grade III pollution incidents include those which: cause at least three deaths or more than ten cases of serious poisoning; necessitate the moving of more than 5,000 people; cause direct economic losses of more than RMB5 million; cause serious damage to protected animal or plant species; result in the interruption of concentrated drinking water supplies at the township level; involve environmental impacts due to the loss, theft or loss of control of three types of radioactive substances; or have impacts that cross municipal boundaries (MEP 2011a: author's translation).
- ²⁸ MEP 2011a.
- ²⁹ The media attention to lead poisoning was preceded by a number of academic articles. See e.g. Zhang, Jinliang and He 2009; Shen et al. 1996.
- ³⁰ For example, most studies use access to piped water as a proxy for water quality, when water sources may in fact be polluted: World Bank and SEPA 2007; WHO and UN Development Programme 2001. For further discussion of data, see Holdaway 2010a; and FORHEAD 2010.
- ³¹ Xinhua 2010.
- ³² MEP 2011a.
- ³³ FORHEAD 2010.
- ³⁴ Zhen et al 2013; Matus et al. 2011; Zhang Junfeng et al. 2010; World Bank 2007; Ho and Nielsen 2007.
- ³⁵ For the rural situation, see Su and Duan 2012; FORHEAD 2010.
- ³⁶ MEP 2011a: 5% of the MEP's budget for science and technology development (RMB10 billion) is devoted specifically to environment and health, with a focus on heavy metals, Persistent Organic Pollutants and regionally specific risk assessment; many other items are also related.
- ³⁷ The lack of integrated monitoring systems to support assessments of pollution risks to health is also discussed in the MEP Environmental Protection and Health Work Plan. On recent developments in information disclosure, see Mol, He and Zhang 2011; Institute of Public and Environmental Affairs and Natural Resources Defense Council 2008.
- ³⁸ Liu, Xianbing et al. 2011; Dong et al. 2011.
- ³⁹ FORHEAD 2010.
- ⁴⁰ Yang, Gonghuan 2011. The study indicates that patterns of disease closely follow the flow of rivers, with concentrations of pollution sources combining with differences in water volume, population density, and other factors, to cause high levels of exposure and rates of disease in particular places.
- ⁴¹ Zhen et al 2013; CCICED 2012; Zhang et al 2010;
- ⁴² Su and Duan 2010.
- ⁴³ Ibid.
- ⁴⁴ Holdaway and Marshall 2010.

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- ⁴⁵ A number of studies analyse the changing nature of environmental risk factors at different levels of development (e.g. Smith and Ezatti 2005). However, of the framings referred to in footnote 9 above, only the UNEP GEO Health methodology considers in detail not only the level, but also the type of development.
- ⁴⁶ Holdaway and Marshall 2010.
- ⁴⁷ Tilt 2007; van Rooij 2006.
- ⁴⁸ Holdaway 2010b.
- ⁴⁹ Kingdon 2010.
- ⁵⁰ The term appears to have been first used in the run up to the drafting of the National Action Plan on Environment and Health, which was published in 2007.
- ⁵¹ Ministry of Health 2007.
- ⁵² It is not clear at the time of writing how much of the requested amount was finally provided.
- ⁵³ MEP 2011a.
- ⁵⁴ CCCPC 2011; see also FORHEAD feature on “Environment and health in the 12th Five-Year Plan” for relevant sections, <http://www.forhead.org/cn/newsinfo.aspx?NID=1021&ID=1047&Type=law>.
- ⁵⁵ MEP 2011b.
- ⁵⁶ *Zhongguo huanjing bao* 2011.
- ⁵⁷ CCCPC 2011.
- ⁵⁸ For environment and health in the plans of other ministries, see the FORHEAD feature on “Environment and Health in the 12th Five-Year Plan.”
- ⁵⁹ See Su and Duan 2010 for a chart of the various ministry offices with environment and health-related responsibilities; Yang, Gonghuan 2011; FORHEAD 2010.
- ⁶⁰ MOH 2011.
- ⁶¹ MOST 2011.
- ⁶² Holdaway and Marshall 2010.
- ⁶³ Su and Duan 2010.
- ⁶⁴ *Ibid.* 89–92; Fang, Jing and Bloom 2010. Owing to their stronger presence at the local level, CDCs are often the main collaborating agency in environment and health research. Information about the lack of regular funding is drawn from the author’s conversations with CDC officials at the national and local level.
- ⁶⁵ See e.g. Human Rights Watch 2011.
- ⁶⁶ MEP 2011a.
- ⁶⁷ Su and Duan 2010, 89.
- ⁶⁸ See Holdaway and Marshall 2010.
- ⁶⁹ OECD 2006.
- ⁷⁰ Zhang, Xiaobo et al. 2012; Perry and Heilmann 2011.
- ⁷¹ Su and Duan 2010.
- ⁷² CCICED 2012; 2008. OECD 2006
- ⁷³ See Grunow and Heberer 2011 and other articles in the same special issue. It is notable that the summary of environmental policy development by Richard Louis Edmonds does not mention health at all. See also Wu, Fengshi 2009.
- ⁷⁴ Bloom 2011; Duckett 2011; Zhang, Z, Fang and Bloom 2009; Wagstaff et al. 2009.
- ⁷⁵ World Bank 2011.
- ⁷⁶ Fang, Jing and Bloom 2010. However, there have been calls for more comprehensive health assessments of policy initiatives. See e.g. Wu, Rutherford and Chu 2011.
- ⁷⁷ Wang, M et al. 2008; Tilt 2007; van Rooij 2006; Han and Lei 2006.
- ⁷⁸ Ho, Peter and Vermeer 2006; Smil 1993.
- ⁷⁹ Bryan Tilt has made the largest contribution in terms of detailing these linkages. See Tilt 2007.
- ⁸⁰ Liu, Hui 2011.
- ⁸¹ Perry and Heilmann, 2011, 11.
- ⁸² See Lora-Wainwright 2013; also Lora-Wainwright et al. 2012.
- ⁸³ Chen and Cheng 2011; see also Liu, Xianbing et al. 2011; and Dong et al. 2011.
- ⁸⁴ Early findings from an interdisciplinary study in Fenghuang county, supported by the SSRC China Environment and Health Initiative Collaborative Grants Programme.
- ⁸⁵ Lora-Wainwright 2013; Lora-Wainwright et al. 2012; Chen and Cheng 2011.
- ⁸⁶ Jing 2000; ; Lora-Wainwright 2013; van Rooij 2011, 193–219.
- ⁸⁷ Tilt 2006; van Rooij 2011, 193–219; Chen and Cheng 2011.
- ⁸⁸ Dasgupta and Wheeler 1997; Dong et al. 2011; Liu, Xianbing et al. 2011.
- ⁸⁹ See Deng and Yang 2013; Lora-Wainwright 2013; Chen and Cheng 2011.
- ⁹⁰ Chen and Cheng 2011.
- ⁹¹ Yang, Guobin 2010; Yang, Guobin and Calhoun 2008.

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- ⁹² See Deng and Yang 2013, Lora-Wainwright 2013.
- ⁹³ Chen and Cheng 2011; Lora-Wainwright 2013.
- ⁹⁴ Ho, Peter and Edmonds 2008, 216–222; Edmonds 2011.
- ⁹⁵ Chen and Cheng 2011; see also Lora-Wainwright 2013; Klein 2013.
- ⁹⁶ Yang, Guobin 2013.
- ⁹⁷ See e.g. Tesh 2000; Irwin and Wynne 1996; Leach, Scoones and Wynne 2005; Brown and Mikkelsen 1992; Brown 2007.
- ⁹⁸ Fang, Pengqian et al. 2010.
- ⁹⁹ Holdaway 2011; Holdaway and Marshall 2010.
- ¹⁰⁰ Smith and Ezzati 2005.
- ¹⁰¹ Holdaway and Marshall 2010.
- ¹⁰² Ma 2010; Schoolman and Ma 2012; Chen, Chen and Landry 2012.
- ¹⁰³ Chen and Cheng 2011; van Rooij 2012; Lora-Wainwright 2013; Tilt 2006.
- ¹⁰⁴ Zhang, Yingying 2011. Liu Lican’s sites were chosen on the basis of media reports.
- ¹⁰⁵ Chen Aijiang’s study of five “cancer villages” illuminates this tension (Chen and Cheng 2011). See also Lora-Wainwright 2013.
- ¹⁰⁶ See e.g. Greenpeace 2010; and IPE and NRDC 2011.
- ¹⁰⁷ Li 2011.
- ¹⁰⁸ Yang, Guobin 2010.
- ¹⁰⁹ Tesh 2000.
- ¹¹⁰ Benjamin van Rooij and James Keeley alerted me to the absence of research on these issues.
- ¹¹¹ Holdaway and Marshall 2010.
- ¹¹² Grunow 2011.
- ¹¹³ Bramall 2008; 2003.
- ¹¹⁴ Holdaway 2012b.
- ¹¹⁵ Holdaway and Marshall 2010.
- ¹¹⁶ FORHEAD 2010.
- ¹¹⁷ For example, the DFID–ESRC–NERC-funded Ecosystems Services and Poverty Alleviation Program, which has a health stream. Also, the EcoHealth programme supported by the International Development Research Centre.
- ¹¹⁸ These comments reflect my own experiences of participating in and facilitating international and interdisciplinary exchanges, as well as engagement through the FORHEAD network with a wide range of users of research in government, NGOs and the media. For literature on interdisciplinary research, see Charron 2012; Thompson Klein 1990; Kockelmanns 1979.
- ¹¹⁹ Kuijper 2010.
- ¹²⁰ Charron 2012.
- ¹²¹ There is no comprehensive data, but researchers from the Chinese Academy of Sciences have estimated that as much as 10% of China’s agricultural land, and a much higher percentage in the south, may be contaminated with heavy metals, see http://english.caixin.cn/2011-02-16/100226177_3.html. See also CCICED 2010.
- ¹²² CCICED 2012.
- ¹²³ Ibid.
- ¹²⁴ Liu, Hui 2011; Holdaway and Marshall 2010.
- ¹²⁵ Delayed health effects can be seen quite clearly in the Huaihe study, where cancer rates are highest in areas where pollution is already coming under control. See Yang, Gonghuan 2011.
- ¹²⁶ An example is the five-year remediation project undertaken in Mentougou county on the outskirts of Beijing at a cost of RMB 1.3 billion for 615 square kilometres (*Shengtai Renlei* November 2009). See World Bank 2010 for a discussion of the remediation of polluted sites in several Chinese cities.
- ¹²⁷ The same situation applies with the costs of rural–urban migration. See Holdaway 2010b.