GLOBAL WARMING, GLACIERS AND GOLD MINING

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ABSTRACT

Two case studies (Kumtor in the Kyrgyz Republic and Pascua-Lama in Chile–Argentina) are analysed, illustrating how gold mining interferes with glaciers and how this may be affected by changing perceptions on global warming. Although global warming presents new opportunities for the mining industry, increasing the physical accessibility of resources previously covered with glaciers, it may also limit this accessibility in consequence of changing societal preferences towards the preservation of increasingly scarce glaciers. Whether these preferences can affect gold mining, depends on a number of site and time specific factors.

Key words: glaciers / Kumtor / Pascua-Lama / gold mining / non-use value / existence value

INTRODUCTION

Increased awareness of the consequences of global warming leads to new societal perceptions of the value of environmental goods and services, such as those related to glaciers. New sets of preferences are revealed by consumers with reference to these environmental goods and services where political, economic or social circumstances make it possible. Although it may be impossible to use these preferences directly to elicit the values of such environmental goods and services, they do reflect a trend related to global warming – that demand for environmental goods and services increases with increased awareness of their scarcity and importance.

Glaciers are at risk of global warming and occasional economic undertakings. Large-scale gold mining provides an example of the latter and although few cases have been recorded where mining interfered with glaciers, this risk increases, stimulated by economic incentives to exploit deposits previously unprofitable. Although changes in glaciers' area and volume introduced by mining are minor compared to those introduced by global warming, the society can more easily counteract them. However, this does not always happen. Thus, the underlying hypothesis is that the political motives to protect glaciers from gold mining differ across time and space. Two gold mines (Kumtor in the Kyrgyz Republic and Pascua-Lama in Chile/Argentina) provide useful case studies. When the construction of Kumtor mine started in the early 1990s, not many people expressed concern about the fact that some glaciers would have to be destroyed. Ten years later, when Pascua Lama was projected, this issue spurred much more attention and led to the legal protection of endangered glaciers on the site.

The study is based on literature review and direct consultations with stakeholders. Although societal preferences towards glaciers have not been quantified, it is assumed that public acceptance or opposition towards gold mining projects interfering with glaciers reflects these preferences, at least to some extent.

This paper first reviews services generated by glaciers, types of their values and how these values might affect the political motives to protect glaciers. The next section inspects how mining might interfere with glaciers, which is illustrated by the overviews of Kumtor and Pascua Lama gold mines. Then, the circumstances that led to different perceptions of glaciers in the two

case studies are discussed. The last section concludes with some remarks on how the revealed preferences towards glaciers could be used to preserve them for the benefit of glaciated regions.

SERVICES PROVIDED BY GLACIERS

Reviewing the services provided by glaciers (Table 1) reveals various use and non-use values that might be assigned to the stocks of glaciers and the flows of glacier runoff, and the character of the related economic benefits. These benefits can have direct or indirect character and can be valued with market or non-market valuation techniques respectively. Eventually, whether expressed, calculated or not, these values translate into political motives to protect glaciers.

Table 1 Glaciers' services and their valuation

Character of economic value	Service	Potential valuation method
Use value	Source of fresh water	Market valuation
	Contributing to the regulation of climate	Market valuation
	Tourism	Market and non-market valuation
	Information about the history of the Earth and about the behaviour of climate	Market and non-market valuation
	Preservation of specimens of past life forms	Market and non-market valuation
Non-use value	Existence value	Non-market valuation
	Bequest value	Non-market valuation
	Altruistic value	Non-market valuation
Negative value	Creating a barrier to the development of a given project	Market and non-market valuation

Glaciers are probably best known for being the source of fresh water, which is particularly important in arid regions (indeed, glaciers constitute the primary source of water in both regions referred to in the case studies below). They accumulate and store water that can potentially be used in the future, thus also contributing to the regulation of climate – reducing temperature and increasing precipitations. To emphasise this hydrological perspective, mountains are sometimes referred to as 'water towers' of the world (e.g. Messerli et al., 2004). Market valuation might be used to price this function as it is crucial for agriculture, energy generation and other economic sectors dependent on water, and indeed also for human survival.

Tourism opportunities offered by glaciers, such as skiing, ice-climbing and trekking, constitute another important example of a use value. In this case, both market and non-market valuation techniques might be employed, studying the economic benefits achieved by regions with glaciers or surveying the preferences of individual tourists using glaciers. The most unusual (the largest, the most scenic) and the most accessible glaciers would score the highest values.[1]

Another example of a use value, though more difficult to estimate, is glaciers' ability to provide information about the history of the Earth and about the behaviour of climate. Currently, glaciers are frequently used as an indicator of global warming. They also offer a potential study material for various sediments reflecting the atmospheric conditions in the past, and sometimes uncover spectacular specimens of past life forms (including now extinct animals and earlier

[1] Shaping the Earth's surface by glaciers can also contribute to making some regions more touristically attractive. However, this function operates in time scales too large to be incorporated in most valuation studies and it mostly refers to the past activity of glaciers rather than the current one.

people). In both cases, non-market valuation techniques might be useful, while in the latter market values might also emerge if uncovered specimens were shown in museums or other exhibitions, thus generating economic benefits in terms of ticket sales.

Existence, bequest and altruistic values represent the non-use values of glaciers. For people concerned with environmental issues, it is important to know that glaciers exist, even if most of them would not personally use a glacier. With growing awareness of global warming resulting in glaciers' melting, these values tend to increase. The remaining glaciers are likely to be worth more in the future, and people are interested in leaving this 'treasure' for future generations or for other, contemporary people depending on them as a source of water. Additionally, for some indigenous peoples, peaks covered by glaciers are revered as religious symbols (Vergara et al., 2007). Such a spiritual value is also perceived by some people of the modern society (Ehrlich, 2004; Orlove et al., 2008). Although these values are difficult to account for, they might be revealed with non-market techniques such as contingent valuation.

Alternatively, from the perspective of an individual company rather than the whole society, glaciers may create a barrier to the development of a given project. In this way, they would prevent the company from realizing a value associated with an alternative land use. For example, describing the times of the early US settlement in Alaska, Martin (1913) classified glaciers, among other things, as barriers to communication, transportation (railroads, roads, waterways), plant and animal life, hydropower, and as forces destroying ports and settlements.[2] In particular, this view has been expressed with relation to mining, which also dates back to the early times of mining expansion to areas previously difficult to access (Martin, 1913, p. 812; Eyles and Rogerson, 1977a,b; Clarke and Holdsworth, 2002, p. J296). Such a negative value of a glacier might be revealed in market valuation (losses directly incurred as a result of glacier activity) or in non-market valuation (statements expressed by the affected).

Benefits that people derive from glaciers (or, in the last of the above cases, from glaciers' loss) are affected by decisions that people make. Reducing the stocks of glaciers, limits future availability of water (flow) and leads to changing local climates. The vulnerability of people dependent on glacier water to climate change may bring about economic costs, such as increased risk of conflicts, increased migration and food insecurity (Messerli et al., 2004). Furthermore, water originating from glacier runoff in some countries (e.g. the Kyrgyz Republic or Tajikistan) is then used in neighbouring countries or sold to them in the form of hydropower. Glaciers' melting will undermine market benefits currently emerging from this exchange. Vergara et al., (2007) calculated the economic consequences of glacier retreat in Peru looking at the costs of replacing hydropower by alternative energy sources and the costs of rationing energy in the transition period. Conversely, glaciers' melting with global warming can also lead to increased mining opportunities in places previously covered with glaciers, as the example of current mining boom in Greenland demonstrates (Mining Journal, 2008).

Eventually, the value of glaciers and the preferences towards glaciers are affected by uncertainty about their future dimensions and ability to provide their services. They also suffer from the widespread ignorance regarding glaciers' functions, as well as their fragility and vulnerability. Lack of valuation, inadequate valuation or inadequate expression of preferences bring about the risk of further degradation with the introduction of large scale environmentally intrusive projects, including gold mining.

[2] An even earlier example refers to the early Norse settlements in Greenland and their failed attempts to colonise North America around AD 1000 (Diamond, 1997, pp. 371–372).

DATA: MINING AND GLACIERS

With technological progress, and growing demand and prices, new mining projects open in areas the exploitation of which has not been feasible so far. This also includes sites covered with glaciers, which additionally become more accessible with global warming.

Mining which might potentially affect valuable natural sites has always raised controversy, and areas with glaciers have been no exception, as demonstrated by the long-lasting debates on mining in the then Glacier Peak Wilderness Area (Washington State) or in the then Glacier Bay National Monument (Alaska) (see e.g. Sperry, 1967; Carter, 1968; Liska et al., 1968). The extent of controversy depended on information availability regarding mining projects potentially interfering with glaciers or destroying areas otherwise valuable because of glaciers.

The two case studies analysed in this paper are not exceptional, in that there are other mining projects in the world that affect glaciers. Mining under glaciers happens, both in the mountains (e.g. Clarke and Holdsworth, 2002; Brenning, 2008) and in polar regions (e.g. Melvold et al., 2003; Christiansen et al., 2005). However, except for the examples referred to by Brenning (2008), the above refer to underground mining, under the earth covered by glaciers, which affects glaciers less than open pit mining adopted in both Kumtor and Pascua-Lama.

The following case studies, one of an operating mine (Kumtor) and the other under construction (Pascua-Lama), originate from high mountain areas covered with glaciers and surrounded by arid regions. They provide an illustration of how mining can interfere with glaciers and what different attitudes towards this interference may emerge, reflecting the perceived value of glaciers. The two subsections below present both projects, followed by an analysis of their implications for the protection of glaciers.

Kumtor

In 1992, the Government of the Kyrgyz Republic signed an agreement with Cameco, a uranium company, creating Kumtor Gold Company. Subsequent discussions led to many changes in the feasibility study originally presented by Cameco (Sarygulov, 2000, pp. 168–174), however no similar discussions took place on the project's EIA. Construction started towards the end of 1994 and commercial production started in May 1997. Since then, until the end of 2007, the mine has produced 6.2 million ounces of gold (Bruce et al., 2008). Constant exploration and growing gold prices (through reducing the cut-off grade) have contributed to significantly enlarging the mine's reserves and the number of pits. The mine is currently planned to operate until 2014.

The mine is located in the Tien Shan mountains, in the east of the Kyrgyz Republic (41º52'N, 78º11'E). It lies at an elevation of 3600–4400 metres above sea level, in the zone of active glaciers and permafrost reaching 100–250 metres of depth (Torgoev and Aleshin, 2001; Bruce et al., 2008). Two peculiarities of the Kumtor mine refer to glaciers: removing glaciers and storing waste on those that remain.

As the pit's outline included some area covered with glaciers, these had to be removed. In fact, glacier ice needed to be removed beyond the pit's outline, to protect the mine from glacier flow. When construction started, the maximum glacier depth over the future mine was 40 metres. Until the end of 2007, in addition to 59.5 million tonnes of ore and 639 million tonnes of waste rock, 5.9 million m3 of glacier ice were also extracted (Bruce et al., 2008, p. 37). The initial plans mentioned removing 10 million m3 of glacier ice (Torgoev and Aleshin, 2001, p. 102). Glaciers were broken with traditional explosions.

Since the beginning of mine construction, glaciers were charged with waste rock, both as a means of disposing of waste rock as close to the pit as possible in order to reduce transportation costs, and as a way of directing glaciers away from the pit (and creating a barrier separating the

mining area from active glacier). The proximity of waste rock dumps has helped to keep operating costs low until 2005 (Sarygulov, 2000, p. 175; Thalenhorst and Farquharson, 2004, p. 2; Bruce et al., 2008, p. 115). This glacier 'engineering' has helped effectively to protect the mine, and it is planned to continue (Bruce et al., 2008, p. 74). Nevertheless, glacier-related risks persist, the most important of which being the instability of pit walls. The most significant pit wall failures occurred in 2002 and 2006, resulting in one fatality, substantial decreases in production and increased costs. As water seeping from the overlying glacier reduces the scope of permafrost, and thus contributes to this risk, more ice is scheduled to be removed from the overlying glacier and melting water is scheduled to be directed away from the pit (Bruce et al., 2008, p. 5–6).

Other, potential problems related to the activity of Kumtor mine refer to the increased melting of surrounding glaciers and acid leakage. The former might result from the estimated 3–4 tons of dust, emitted daily at the mine site (Torgoev and Aleshin, 2001, p. 51–52), as well as from transportation and exploration (Bogdetsky, 2001, p. 61). According to Dikikh (2001), this might affect glaciers in the radius of 60–100 km, or even more. However, this albedo-decreasing effect of dust might be neutralised by the relatively high precipitation in this area (Aizen et al., 1995; 1997). The latter, an environmental problem caused by many gold mines in the world, can possibly be exacerbated at Kumtor by the fact of storing waste rock on glaciers and consequent pollution of surface water and ground water (Torgoev and Aleshin, 2001, p. 76). However, this is refuted in the mine's technical reports (e.g. Thalenhorst and Farquharson, 2004, p. 65; Bruce et al., 2008, p. 115).

The three active glaciers directly affected by the mine are: Lysyi, Davidov and Sary-Tor. They form part of the Ak-shirak range which is estimated to have lost 8.6% (35.15 km2) of its glaciers' area between 1977 and 2003 (Aizen et al., 2006). According to other estimates, 23% of Ak-shirak glaciers' area was lost between 1977 and 2001 (Khromova et al., 2003), but the reliability of these results has been questioned (Khalsa et al. 2004; Aizen et al. 2006). Kumtor mine's contribution to this loss was estimated at around 0.7 km2 of ice (Khromova et al., 2003), about 2–4% of the entire area loss in the Ak-shirak range. In terms of volume of ice destroyed, the mine's total contribution is 0.09–0.16% (according to Aizen et al. (2006), the volume of Ak-shirak glaciers diminished by 6.147 km3 between 1977 and 2000). If this contribution seems small, it is because Ak-shirak is the second largest glaciarised massif in the Tien Shan and it is compared to the period of glacier change longer than that of mine's operation.

Pascua-Lama

More recently another company, Barrick Gold, decided to mine gold (and other minerals) in an area covered by glaciers. In this case, significantly less ice was supposed to be removed (830,000 m3, according to 2005 plans) and the glaciers under consideration were already in the process of disappearing. Nevertheless, public attention was drawn to the issue and there was large pressure on the mining company to change its plans so as not to affect the glaciers.

Pascua-Lama mine is located in the Andes, on the Chile–Argentina border (29º19'S, 70º01'W), and the construction started in May 2009. When the mine opens in 2013, its infrastructure and activity will be in both countries, and it will be accessible from both sides. It is located between 3,800 and 5,200 meters above sea level, with glaciers under consideration on the Chilean side.

When Barrick acquired this property in 1994, gold reserves were estimated at 1.8 million ounces, but as a result of exploration, reserves were enlarged to 18.3 million ounces. As of December 2006, Barrick revised reserves downwards to 17 million ounces, to comply with conditions for mine's operation set out by Chilean authorities, regarding the protection of

glaciers. However, in December 2007, as a result of further exploration and increased gold prices, reserves at Pascua-Lama have again been estimated at 17.8 million ounces. The mine is expected to operate for about 25 years, producing around 750,000–800,000 ounces of gold per year in the first five years, as well as far larger quantities of silver, copper and mercury.

Initially, Barrick intended to move the smaller glaciers covering part of the goldfield away from the site and store the ice on the nearby glacier, within the same watershed. This was authorised by the 2001 approval of the EIA (submitted in 2000). Meanwhile, the volume of ice to be transplanted grew from 300,000–500,000 m3 to 830,000 m3, along with the opposition to such an operation from local stakeholders, the international community and the Chilean government. As the conflict between local communities and the mining company intensified, growing attention has been paid to the potential threats posed by the mine to agriculture, the environment and people's health. Removing glaciers symbolised all of these problems. Continuing protests against Pascua-Lama mine led to the discussion in Chilean parliament of a glacier protection law (Harris, 2007). As of May 2009, the law is still under discussion, but a less stringent policy has been adopted. Glaciers became a political issue, with president Michelle Bachelet's declaration that she would not allow the removal or destruction of glaciers in Chile, made during her presidential campaign in 2005 and then repeated after taking office in 2006.

In the final decision of February 2006, Chilean environmental authorities required that Barrick does not remove, destroy, or otherwise physically intervene with glaciers; and protects them and monitors their state (COREMA, 2006). Clearly, it is also not allowed to store waste on glaciers or change their albedo in any way. In response, the company redrew the pit's borders, barring access to approximately 7 per cent of gold deposit and precluding future expansion to the south of the planned pit, and pledged to map and photograph glaciers, study their solar reflectivity and melt water volumes and properties, and monitor microclimate and energy and mass balances (ERM, 2006, pp. 21,24).

The glaciers at Pascua-Lama were described by Barrick as 'small patches of remnant glaciers that are steadily melting in recent climates and more active glaciers 1 to 2 km away from the proposed mine site' (ERM, 2006, p. 4). The 'small patches' are called Toro 1, Toro 2, and Esperanza and cover about 20 hectares of the gold field (with their total area of about 34 hectares). According to the company, 'these bodies of ice have been classified by glaciologists as "glacierets" or "ice reservoirs" rather than traditional glaciers, and consequently their contribution to the water resource of the Huasco Valley is considered to be insignificant' (Barrick, 2009).

Nevertheless, at least partly because of mining exploration and other preparatory work in this area, glaciers already diminished by 50 to 70% of their volume from 1983 to 2003, as revealed by the report of the Ministry of Water and Public Works. Although this must have been influenced by climate change, other glaciers in the area have diminished less significantly (Harris, 2007). With the mine or without it, because of global warming, the three small glaciers are likely to melt within 10 years. Barrick declares that they have already changed the plan and that they would not mine the area currently covered by glaciers even when they are gone (Harris, 2007). However, this may change in the future and constitutes rather an example of public relations activity of the company, building on the revealed preferences towards glaciers.

RESULTS AND DISCUSSION

In the case of Pascua-Lama, the broad movement opposing to the destruction or removal of glaciers led to COREMA's requirement that Barrick changes the mine outline so as to protect the glaciers. Thus, to some extent, societal preferences reflecting the existence, bequest and altruistic values of glaciers have been revealed, as most of the project's overseas opponents would not

have gone to the location to enjoy the scenery, nor would directly benefit from the water that those glaciers provide. Preferences reflecting use values related to water availability expressed by downstream communities were also taken into consideration in the final verdict (glacier runoff provides a long-term stream of benefits). Although these values were not quantified and were not used directly by Chilean decision makers, they played a decisive role as political motives for the authorities to protect glaciers. To some extent, it could even be argued that as glaciers are prime symbols for the (real and demonstrated) threat of global change in a wider sense, it is rather the general political and societal protest that focalizes on the Pasqua-Lama project. This is independent of the use or non-use values of the stocks of glacier ice and the flows of glacier runoff, and independent of the techniques that could be used to assess these values.

However, the fact that these preferences were revealed in the case of Pascua-Lama, and not in the case of Kumtor, suggests that they depend on a number of circumstances that vary from country to country, and from time to time (Table 2). The differences between Chile and the Kyrgyz Republic refer to political traditions, political rights, quality of institutions, the character of public decision making, opportunities for NGO involvement, economic situation (including the significance of the project for the national economy). Finally, awareness and interest in the area of global warming increased significantly between the early 1990s and the early 2000s. This is also confirmed by the fact that other mining projects affecting glaciers in Chile in the early 1990s did not raise interest similar to that in Pascua-Lama (Brenning, 2008).

With better access to information on Pascua-Lama, and exposed to the emotionally laden campaign, the preferences of overseas stakeholders were inflated by ethical considerations (cf. Gowdy, 1997, p. 31). According to Barrick's information, the disputed glaciers contribute an insignificant amount of water, less than 0.5% of the total watershed ('less than 2 litres per second during maximum seasonal melting'; ERM, 2006, p. 21; Fields, 2006, p. A538). Meanwhile, for the global community, it counts that glaciers exist and the information that glaciers were to be removed to facilitate mining in Chile provided a tangible symbol of an additional threat to glaciers which were already exposed to another big threat – global warming. The existence value of glaciers is increasing along with rising awareness of the consequences of global warming, which conforms with the traditional economic perception of prices rising in response to supply being limited.

Relatively few glaciers are mined and thus there are few opportunities for similar cases to occur in the future. The isolation of the case of Pascua-Lama, as compared here with the other mining project, interfering with glaciers to a far larger extent, demonstrates that gold mining rarely can provide additional motives for the protection of glaciers. Also, glaciers differ with regard to their geophysical properties, resulting in diversified vulnerability to climate change (smaller glaciers being more vulnerable). The values of individual glaciers are likely to be site-specific and depend on a wide range of factors. Global warming affects the perceived values of glaciers to a far larger extent than mining (and it affects all glaciers) but, through its impact on glaciers, it also affects mining projects. On the one hand, this refers to making some resources (previously covered with glaciers) more accessible, but on the other hand, it may preclude (at least temporarily) the access to other resources, because of potential public opposition to interfering with increasingly scarce glaciers.

Table 2 Differences between Chile and the Kyrgyz Republic that led to different approaches to mining glaciers

Category	Chile	Kyrgyz Republic
Political tradition	Liberal approach.	Top-down authoritarian approach, partly inherited from the USSR.
Political rights, civil liberties	Since the beginning of the 1990s, Chile has been classified as a free country with regard to political rights and civil liberties, and since 2003 it has achieved the maximum scores in both categories (Freedom House, 2009). This translates into freedom of speech and opportunities to protest for the local communities to be affected by mine's operations.	In the same time, the Kyrgyz Republic has been classified as either non free or only partly free, with particularly low scores since 1998 (Freedom House, 2009). Opportunities for spontaneous protests against the project were very limited (lack of civil society, strong inheritances from the Soviet Union).
Quality of institutions	With longer tradition of democracy, Chile is often praised for the quality of its institutions, also reflected in low corruption (Corruption Perception Index scored 6.9–7.5 in a 1–10 scale (10 representing no corruption) for 1995–2008 (Transparency International, 2009)).	Poor quality of institutions in the Kyrgyz Republic (e.g. Dabrowski, 2000; Cokgezen, 2004), with neglect of the basic rules of law and high corruption (Corruption Perception Index scored 1.8–2.3 in a 1–10 scale (10 representing no corruption) for 1999–2008 (Transparency International, 2009)).
Public decision making process	Over 400 conditions put forward in the final approval of Pascua-Lama project reflect the doubts and questions suggested by various stakeholders. This in turn, reflects the open and transparent decision making process in Chile.	In the case of Kumtor, EIA was not subject to such open debate and indeed it was not widely discussed at all.
Involvement of international NGOs	Presence of international environmental NGOs, coordinated actions, freedom of activity.	Major international environmental NGOs either not active in the Kyrgyz Republic or with low involvement. Involvement of national and international stakeholders increased following the Kumtor sodium cyanide spill accident in 1998.
Economic situation	In 2000, the Chilean GNI per capita was USD 4850 (World Bank data). Most of 1990s was a period of significant economic growth.	In 2000, the Kyrgyz Republic's GNI per capita was USD 280. Over the 1990s, the Kyrgyz Republic struggled with economic recession.
Significance of the project for national economy	Although Pascua-Lama is supposed to become one of the largest gold/silver mines in the world, still it will not be 'the engine of a national economy'.	Over the years of its operation, Kumtor mine contributed up to 10% to the country's GDP, up to 41% to its exports and up to 44% to its industrial production. Significant pit wall failures in 2002 and 2006 heavily impacted in the rate of economic growth in the country.
Character of the project	Pascua-Lama is operated by a single foreign company.	Until 2004, the Kyrgyz government held 66% of shares in Kumtor Gold Company.
Reporting	Barrick's reports plus intensive public relations work in response to reservations expressed by local populations and NGOs.	Since 1999, Kumtor prints several copies of hardly accessible annual environmental reports. Very limited transparency.
Additional circumstances	An emotionally written and rather imprecise chain email in the case of Pascua-Lama contributed to worldwide attention to the issue.	Mining takes place close to the sources of one of the main rivers of Central Asia – Naryn (which later joins with Kara-Darya to form Syr-Darya). Thus, large-scale gold mining has been listed among three most important environmental problems in the Kyrgyz Republic (OSCE et al. 2003), and consequently also in other Central Asian countries.

CONCLUSIONS

Gold mining can help to reveal societal preferences towards glaciers by drawing people's attention to the issue of glacier destruction and potentially eliciting the values they attach to glaciers. The perceived value of an environmental good or service depends on political and social circumstances that affect the possibility of revealing the relevant preferences. The value of glaciers is not always perceived by local populations, even if they depend on them as a source of fresh water. Meanwhile, overseas stakeholders, as well as national stakeholders in the case of poor democratic systems, may not have enough information or opportunities to express their concerns and reveal preferences. Other factors that led to the disparity of interest and opposition in both cases reflected larger market, government and social empowerment failures in the Kyrgyz Republic.

As Pascua-Lama constitutes a precedent, it is uncertain whether this experience could be replicated elsewhere. Kumtor provides an immediate counterexample; a law on the protection and monitoring of glaciers passed by Argentinian congress in October 2008 and vetoed by the president in November 2008 on the basis that it might threaten economic development – yet another. Nevertheless, the case of Pascua-Lama incited a wider discussion on glaciers and their protection in countries where mining or other economic development activities might interfere with glaciers. Indeed, this approach could be used within a framework for discussing the economic impacts of, and responses to, global warming on a regional scale (Abler et al. 2000).

As new resources are being explored in areas where mining used not to be financially or politically viable, increased international scrutiny is necessary in studying the impacts of mining. Estimating the value of glaciers and their services would facilitate other future decisions regarding interfering with glaciers. In particular, this refers to mining in poorer countries where democracy is poorly developed. Indeed, the work on two documents of the Kyrgyz government might also benefit from such estimates:

- a new law that aims at creating a register of the country's strategic assets, with an idea that glaciers should also be registered in this list; and
- a national programme on preservation of the quality and volume of glaciers, snowfields and permafrost in mountain ecosystems.

Referring to the value of glaciers, upstream countries might seek compensation from downstream countries for foregoing large-scale environmentally risky projects. Countries with gold reserves under glaciers might seek compensation from gold using countries for foregoing projects destroying glaciers, based on the preferences towards glaciers revealed by stakeholders originating from the latter. Impacts on glaciers, and thus water availability in the future, should be incorporated in the relevant environmental impact assessments, cost–benefit analyses, and life-cycle assessments. The relevant product information could be used in product-oriented environmental policies, in an attempt to make overseas consumers effectively reveal their preferences and choose gold the extraction of which did not affect glaciers.

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