The impact of climate change on the transport sector is relatively unstudied compared to other areas. Changes will lead to geographic shifts in volume rather than overall losses. Apparent net negative effects relate to losses incurred through increasing costs of logistics for inland transport, as some important river levels decline. These losses are not expected to be offset by gains in transport effectiveness in parts of the world experiencing more flooding of river-ways due to climate change. Water resource management and conservation are required to limit these effects.
Only the impact of climate change on river transport is considered here. Many other negative and positive effects of climate change on the transportation sector are conceivable, but difficult to simulate (Koetse and Rietveld, 2009; Eisenack et al., 2012). Climate change, however, can clearly affect the flow of rivers, increasing or decreasing the rate and volume of water over which goods are transported (Stromberg et al., 2010). A number of the world’s waterways are already independently stressed due to infrastructure, pollution, or water withdrawals, which can reduce river flows and make them more vulnerable to climate change impacts (Palmer et al., 2008; Sabater and Tockner, 2010).

Climate change has been simulated to have potentially serious negative effects on the river levels of some of the world’s most important waterways, including the Danube, the Rhine, and the Rio Grande rivers (Nohara et al., 2006). Lower water levels will continue to increase water levels in the world’s rivers. Increased rainfall and heavy flooding will also affect rivers in some places. However, there is little evidence of any beneficial effect from higher river levels, which are more likely to increase flooding and other risks, since most additional water will fall during the rainy season, when flows and supply are in abundance (Arnell, 2004). When river levels decline, an economic loss arises by affecting the maximum cargo payload that can be transported, or the size of ships transporting goods. The inefficiencies thus created increase shipping costs in a predictable way (Jonkeren et al., 2007).

Impacts

Only a handful of countries are affected in any significant way by the impact of climate change on river transportation. This is because large-volume, inland, water-borne transportation is a major economic activity in only a few river basins of the world (UNECE, 2012a). Moreover, only a small number of river basins are currently projected to see continued decline, mainly because in many areas rainfall will increase with climate change (Nohara et al., 2006). The costs of climate change on the transport sector as a result of effects for inland water-borne logistics are currently estimated at 1 billion dollars per year, increasing to over 7 billion dollars by 2030 as the effect intensifies and the overall impact grows as a share of GDP. The bulk of all losses are estimated to be incurred in the United States, with European countries along the Rhine and Danube, such as Germany and the Netherlands, as well as Bulgaria and Romania, affected to lesser degrees. Mexico also shows high levels of vulnerability, linked to decline of the Rio Grande. Caution is suggested with regard to the assessment results, which may underestimate the vulnerabilities of several river basins if rainfall patterns were to evolve differently than expected, based on the research relied upon here.

The Broader Context

Many factors other than climate change—especially water withdrawals from rivers due to growth in agricultural, industrial, and municipal water demand—can play a central role in the level of rivers (Alcamo et al., 2003). Indeed, so-called “basin” closure—the inability of a waterway to meet local water demands for part of the year—currently affects 1.4 billion people in various river basins around the world (Falkenmark and Molden, 2008). Population growth exacerbates these issues when alternate resources are not adequately managed (Voßösmarty et al., 2000; Palmer et al., 2008). The transportation and logistics sector is a steady growth industry in a globalizing economy, with no expectation of declining demand, except for passenger transportation in some industrialized country settings (US DoT, 2010; Millard-Ball and Schipper, 2011). Therefore, losses are unlikely to lead to unemployment issues, but rather to generate additional costs for communities that have relied on highly efficient inland water-borne transportation, which can be a major economic benefit.
**VULNERABILITIES AND WIDER OUTCOMES**

In arid regions, water demand for irrigation has an amplified effect on river levels (Kang et al., 2004). Africa may be particularly vulnerable as a result (de Wit and Stankiewicz, 2006). Smaller rivers may also be asymmetrically affected (Pandey et al., 2010). Free-flowing rivers are more resilient than riverways with dams (Palmer et al., 2008). Deforestation or expanded agricultural and industrial activity can further lower resilience to any shocks and river-level decline brought on by climate change (Sahin and Hall, 1996; Conway, 2005). As the effects are currently interpreted, the narrow economic impact is not expected to have many discernable wider outcomes, aside from burdening a handful of countries/communities with additional costs.

**RESPONSES**

With glacial retreat, growing heat, and rainfall decline out of societal control, responses would likely include some form or combination of water resource management and the enhancement of catchment potential (Palmer et al., 2008; Falkenmark and Molden, 2012). Water resource management could seek to minimize or reduce water withdrawals, especially during high summer or drought periods, as well as increase water re-use and reduce water contaminants from industrial or agricultural sources (Geng et al., 2001; F-tiered; 2001; Asano, 2002). Government quotas on irrigation could stimulate broader use of micro-irrigation and other water conservation actions (Pereira et al., 2002; Barret and Wallace, 2011). Water catchment potential can be enhanced through such measures as large-scale forestry expansion and conservation (Sahin and Hall, 1996). Limiting riverine infrastructure also improves resilience (Palmer et al., 2008).

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**THE INDICATOR**

The indicator is considered uncertain and speculative for those countries assessed—provided projections for river flow and levels are accurate (Nohara et al., 2006). The economic effect of river decline relies on a study conducted in the Netherlands, not global research (Jonkeren et al., 2007). But the main limitation of the transport sector indicator relates to its scope, as increasing severity and variability of weather, growing heat stress, and other elements will likely affect the transport industry. Growing tire failure, increased delays and congestion, accidents, and port infrastructure damage have not been studied sufficiently to build even speculative indicators of global effects (Koetse and Rietveld 2009; Eisenack et al., 2012). The rapid opening of previously inaccessible Arctic passageways will likely benefit, but its dynamics are difficult to ascertain (Macdonald et al., 2005). Additional investigation is needed to better understand the global effects of climate change on the transport sector.
CLIMATE VULNERABILITY

Vulnerability measure:
comparative losses as a share of GDP in USD (national)

CLIMATE UNCERTAINTY

TRANSPORT

Vulnerability measure:
comparative losses as a share of GDP in USD (national)