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Energy prices and seafood security

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ABSTRACT

Fish resources are critical to the food security of many nations. Similar to most contemporary food systems, many fisheries and aquaculture resource supply chains are heavily dependent on fossil fuels. Energy price increases and volatility may hence undermine food security in some contexts. Here, we explore the relationships between energy price changes, fish resource supply chain viability, seafood availability and food security outcomes – both for producers and consumers of fish resources. We begin by characterizing the energy intensities of fish resource supply chains, which are shown to be highly variable. We subsequently assess the comparative magnitude and distribution of potential food security impacts of energy price increases for nation states by scoring and ranking countries against a set of vulnerability criteria including metrics of national exposure, sensitivity and adaptive capacity. Considerable variability in the vulnerability of populations and high levels of exposure for already food-insecure populations are apparent. Developed countries are likely to be most exposed to the effects of energy price increases due to their high rates of fleet motorization and preference for energy-intensive seafood products. However, heavy reliance on seafood as a source of food and income, as well as limited national adaptive capacity, translates into greater overall vulnerability in developing countries. At the level of individual producers, a variety of adaptation options are available that may serve to reduce vulnerability to energy price changes and hence contribute to increased food security for producers and consumers, but uptake capacity depends on numerous situational factors.

1. Introduction

Increasing energy prices and energy price volatility are becoming hallmark characteristics of the global economic system (Hall and Klitgaard, 2006; Weller and Fields, 2011). Contributing factors include: declining availability of easily accessible fossil fuels and associated geopolitical tensions; climatic instability and related natural disasters that impact on energy infrastructure; and the inter-linkages between energy-dependent economic growth, population growth, and changing consumption patterns toward more energy-intensive lifestyles (Hall and Klitgaard, 2006; Baffes, 2007; Pelletier et al., 2011). In light of the energy-intensity of contemporary food systems, the implications for food security merit closer attention (Pollan, 2006; Neff et al., 2011; Pelletier et al., 2011).

Food security refers to a state of universal "physical, social and economic access to sufficient, safe and nutritious food that meets dietary needs and food preferences for an active and healthy life" (FAO, 2002). Stability of supply and accessibility are two key components of food security. Stability of supply – whether from domestic food production or imports – is influenced by price volatility (Nellemann et al., 2009). Price volatility often motivates producers to use poor investment strategies because formulating rational plans for the future is confounded by uncertainty (Weller and Fields, 2011). In turn, sub-optimal investment strategies undermine food supply stability. Accessibility is often largely determined by affordability. This is of particular concern in developing countries, where a disproportionate share of income – 50–80% in the most impoverished households – is allocated to food

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purchases (Nellemann et al., 2009; FAO, 2011a). In such contexts, a doubling of food prices – as was seen during the 2008–2009 food price spikes – has severe impacts on food accessibility. The predicted rising trend in food prices over the next decade is, in this light, particularly concerning vis-à-vis food security outcomes (OECD-FAO, 2012).

Food prices are determined at the intersection of multiple factors (Abbot et al., 2008; Mitchell, 2008; Gilbert and Morgan, 2010). In counterpoint to the historical downward trend in real food prices due to productivity gains and trade-induced competition, recent food price hikes have been strongly influenced by rising energy costs (Deike et al., 2008; Goldman Sachs, 2008; Mitchell, 2008; Piesse and Thirtle, 2009). Food sector energy use accounts for roughly 32% of global energy use (FAO, 2011a). Nellemann et al. (2009) describe the "cruel irony" of the perverse relationship between energy prices, increased fertilizer and transport costs, and the stimulation of biofuel production, with knock-on poverty and food security implications. Although the as-of-yet limited attention to the relationships between food security and rising energy prices has focused primarily on food production from agricultural systems (Pelletier et al., 2011), seafood production is similarly dependent on fossil fuels.

Nearly half of the world's population derive almost 20% of their protein intake from fish (including aquaculture) resources (FAO, 2012). In low-income food deficit countries, fish accounts for 24% of animal protein intake (FAO, 2012) and 400 million poor people are critically dependent on fish for food (FAO, 2009). Employment in fisheries continues to grow faster than in agriculture, providing direct jobs to an estimated 54.8 million people – mostly in developing countries (Teh and Sumaila, 2011). A large fraction of these are fishers engaged in small-scale fisheries. More broadly, employment associated with fish resource supply chains supports the livelihoods of roughly 10–12% of the global population (FAO, 2012). Clearly, fisheries and aquaculture make vital contributions to food security – both as a direct source of protein, micronutrients and essential fatty acids, and indirectly via employment income for food purchases (Kawarazuka and Bene, 2010; Smith et al., 2010; Garcia and Rosenberg, 2010; Srinivasan et al., 2010). However, the links between fish resource availability and affordability, energy price increases/volatility, and food security outcomes remain an under-considered issue.

Relationships between the energy intensity of food systems and food security outcomes are complex, and vary according to food production technology, geography and socio-economic context (Pelletier et al., 2011). In light of the considerable diversity of fisheries and aquaculture production systems and supply chains, and the varied socio-economic status of producers and consumers of fish products, it can be anticipated that food security outcomes associated with energy price volatility and increases will be similarly variable – as will the capacity to adapt. Here, we evaluate key vulnerabilities of fisheries and aquaculture and, ultimately, those dependent on fish resource supply chains, to energy price volatility and increases with respect to food security outcomes, and highlight opportunities and constraints to supply-side mitigation strategies for fish resource producers.

2. Methods

2.1. Characterizing the energy intensity and distribution of energy use in fish resource supply chains

We begin with a review of factors which determine the energy intensity of fish resource production, processing, and distribution systems, taking into consideration both direct and indirect energy inputs (Section 3.1). We examine major categories of fisheries and aquaculture production in turn in order to elucidate the key drivers of energy use, the extent to which different production systems may be exposed to energy price changes, and where food security impacts may potentially arise. Given that the energy costs of fish products at the storage, retail, consumption and disposal stages are likely similar to those of competing animal protein sources, we focus here on primarily production-related variables.

2.2. Characterizing country-level food security vulnerability at the fisheries viability/fish resource availability/energy price nexus

We subsequently take a global view to classify the vulnerability of countries to fisheries-related food security risks associated with energy price increases in terms of exposure (E) to energy price variations; sensitivity (S), or dependence, of the national economy upon social and economic returns from the fisheries sector; and the extent to which national adaptive capacity (AC) can offset the impact of energy price changes (Section 3.2). Here, we adapted the methods of Allison et al. (2009), which were originally developed to evaluate fisheries vulnerability to climate change. It should be noted that the choice of measures for exposure, sensitivity and adaptive capacity in such an analysis must take into account the scale of the analysis, the sector under consideration and data availability, and is hence somewhat subjective (Allison et al., 2009; Turner et al., 2003). Our selected measures for each of the three components of vulnerability are described below. The variables considered and supporting data sources are summarized in Table 1.

Exposure to energy price change was quantified based on three variables: the national price of fuel; reliance on fuel (i.e. the proportion of the national fleet that is motorized versus non-motorized); and country-specific energy intensities of fish consumption. National energy intensities of fish consumption were calculated as normalized scores out of 1, taking into account country-specific seafood consumption patterns and average energy intensities for seafood categories (e.g. crustaceans, molluscs, pelagic fish, demersal fish).

Sensitivity was calculated using three indices: an index of employment and economic dependence on the fisheries sector; an index of nutritional dependence; and affordability. The fisheries dependence of national economies was represented using a composite index which included fisheries landings, exports and gross revenues, and the contribution of fishing and aquaculture to employment. Nutritional dependence was calculated based on the contribution of fish protein to total dietary protein. Affordability was calculated based on the national food security rating and the household expenditure on food (as proxies for affordability of seafood products for the local population). We assumed that higher landings, exports, gross revenues from fisheries, contribution to employment, dietary protein and household expenditure on food implied a high dependence of the economy on the fisheries sectors and hence a high sensitivity to fluctuations in energy prices in the fisheries sector.

Adaptive capacity (national) was calculated as a composite of five variables: the size of the economy; education; income equality; financial support (subsidies) to the fishery sector; and investment in research and development (R&D) for the agricultural and fisheries sector. These variables were chosen based on the assumption that countries with high levels of economic and human development have the resources and institutions necessary to undertake planned adaptation (Allison et al., 2009).

Full datasets were available for 62 countries. Variables were standardized to obtain a mean of 0 and a standard deviation of 1. The exposure (E), sensitivity (S) and adaptive capacity (AC) indices were calculated as the unweighted sum of the standardized variables, with larger values representing higher levels for a given index.