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Social impacts of earthquakes caused by gas extraction in the Province of Groningen, The Netherlands

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ABSTRACT

Gas extraction from the Groningen gasfield in the northern Netherlands has led to localised earthquakes which are projected to become more severe. The social impacts experienced by local residents include: damage to property; declining house prices; concerns about the chance of dykes breaking; feelings of anxiety and insecurity; health issues; and anger. These social and emotional impacts are exacerbated by the increasing distrust Groningen people have towards the national government and the gas company, NAM, a partnership between Shell and ExxonMobil. The earthquakes have reopened discussions about the distribution of benefits from gas production and the extent to which benefits are retained locally. Mitigation of the impacts is attempted, but the lack of trust decreases the effectiveness of the mitigation measures. The extent of this experience of previously-unforeseen, unanticipated impacts suggests that a new social and environmental impact assessment needs to be undertaken, and a new Social Impact Management Plan (SIMP) and Impacts and Benefits Agreement (IBA) developed, so that the project can regain its legitimacy and social licence to operate. In addition to conventional gas, this paper has wider relevance for unconventional gas developments, for example shale gas extraction by hydraulic fracturing methods (fracking).

Introduction

The northern part of The Netherlands, particularly the Province of Groningen, experienced around 1000 registered minor earthquakes between 1986 and 2013 (KNMI, 2013a). Now accepted as being a consequence of gas extraction (SodM, 2013), these tremors have led to widespread damage to houses and other buildings. Till about 2011, the tremors tended not to be perceived as a major concern, not by the operator, NAM (*Nederlandse Aardolie Maatschappij* or Dutch Petroleum Company), by politicians, or by most of the inhabitants of Groningen province. However, in August 2012, an earthquake measuring 3.6 on the Richter scale, the largest ever recorded in the region, occurred in the village of Huizinge (KNMI, 2013b). This event created much concern amongst local people and gave the earthquakes a much higher priority in the community and in politics (DvhN, 2014a). It led to the Ministry of Economic Affairs commissioning some 15 studies across a range of topics, including geological and economic assessments. The earthquake issue also led to much media publicity in the international and Dutch press, which we use in our analysis in this research. Various academic research projects into the issue have also commenced, especially at the University of Groningen.

In January 2013, the State Supervision of Mines (SodM) published 1 of the 15 reports commissioned by the Ministry of Economic Affairs. The SodM report concluded that continued gas extraction would lead to more frequent and stronger earthquakes than previously experienced. It warned that there was a 7% chance of an earthquake with a magnitude of between 4.0 and 5.0 in the next 12 months (SodM, 2013). The Minister of Economic Affairs, Henk Kamp, stated at the time that a reduction in gas production was not an option, due to contractual commitments (DvhN, 2013a). The economic dependence of the Dutch State on income from gas extraction means that the government is reluctant to reduce output. Nevertheless, the Minister promised he would consider ways to reduce production quickly if it would be necessary (NRC, 2013a).

Publication of the SodM report publically raised the question of how to deal with the earthquakes. The concerns of the affected people became stronger due to the increased anxiety fuelled by the report. As Vanclay (2012) identified, even in situations where people are aware of a project and its implications, the research undertaken for impact assessments can lead people to think more seriously about what the project may mean for them, and this can lead to increased concern and/or opposition they might not have had previously. People in Groningen had known about the earthquakes for years and had lived with them without much concern, but the SodM report with its prognosis of increasing severity of earthquakes and increased impacts led many people to reconsider their opinions, leading to considerable consternation at the local level.

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The increases in the severity and extent of impacts arguably make it necessary to have a new impact assessment procedure, especially one that would focus on management of the impacts (Franks and Vanclay, 2013). The impacts of continued gas extraction on people should be taken seriously. New mitigation measures may be needed to manage the increasingly severe impacts being experienced. Some of the immediate direct environmental consequences of gas extraction are subsidence and earthquakes. Subsidence on its own is not likely to be life threatening, but according to the SodM (2013) report, the earthquakes might be. Even though the risk of a life-threatening earthquake is low, fear and anxiety about the possibility of a strong earthquake is high. The structural damage to buildings from minor earthquakes should also be considered. A significant social impact is the decline in property values for home owners, and their consequent reduced options for the future. While there is a damage compensation plan, the Groningen inhabitants generally feel it is inadequate (DvhN, 2013b).

In this paper, the impacts of the gas production, especially those caused by the earthquakes, are discussed. The first objective of this paper is to consider the direct and indirect impacts on the people of Groningen of the increased risk of earthquakes caused by continued gas extraction. The second objective is to consider the extent to which these impacts are being mitigated and whether such mitigation is adequate. The third objective is to provide recommendations in relation to impact mitigation. In order to accomplish all this, a background to the project and the impacted area is given, including an overview of stakeholders. We also consider the implications for the commercial operator, NAM, and the government partner, especially in terms of their respective levels of public approval, or 'social licence to operate' (Owen and Kemp, 2013; Prno, 2013; Prno and Slocombe, 2012).

The majority of the research and writing of our paper occurred during 2013, with revisions in 2014 when the paper went through the journal review and publication process. As a current and emerging topic, the various issues changed over the course of the research, and the positions of the various actors also changed over that time. We have tried to ensure our paper was accurate as at January 2014, but we note that further changes are likely to occur in the future. Should there be a major earthquake (i.e. greater than 5.0 on the Richter scale), this would have a significant effect on the situation. Firmly based in the discourse of social impact assessment (Esteves et al., 2012; Vanclay, 2003, 2014; Vanclay and Esteves, 2011), especially as it relates to the extractives sector (Esteves and Vanclay, 2009), this paper is not intending to be just a description of a case study, interesting as this case is, rather it is an analysis of the social impacts and mitigation attempts that are likely to be applicable in other situations where unforeseen impacts arise from projects in their operational phases. Thus, although the conventional gas extraction operations in Groningen are very different in technical terms to unconventional gas extraction activities (e.g. shale gas and fracking), to some extent the social issues will be similar, particularly in relation to fear and anxiety. This is what makes this case particularly interesting.

Methodology

The overarching methodological framework is a case study, using a multi-methods approach. Primarily, our analysis is based on a qualitative content analysis of news sources which discuss the impacts of the earthquakes on the people of Groningen. LexisNexis Academic was used to identify initial leads to consider. Each related link was also followed up. We concentrated on local newspapers, especially *Dagblad van het Noorden* (DvhN), using the Dutch equivalents of terms like earthquake, tremor, NAM, gas and gas production. We also used the Google search engine to find items in the international English language media. The search process was non-exclusive and open-ended, in other words, we followed all leads to gain a comprehensive volume of material about the earthquakes in Groningen, rather like a domino or snowball sample. We also scanned the websites of various media outlets, particularly RTVNoord (a regional television station), and local activist groups. Saturation was achieved in the sense that eventually no more new themes emerged, and also in the sense that we had likely read almost everything published about the situation in Groningen.

The research also comprised a substantial document analysis of key company documents, official statements and reports, ministerial statements, and relevant legislation, regulation and procedural manuals. This included the 15 reports commissioned by the Ministry of Economic Affairs, as well as responses to these reports by other agencies, municipalities and local activist organisations.

Another important source of information was a survey of members of the standing market research panel, RegioNoordPanel. The regional paper, *Dagblad van het Noorden*, commissioned a social survey of social issues associated with the earthquakes. The market research company, Enigma Research, and *Dagblad van het Noorden* graciously provided us with the aggregated survey data and permission to use the results. The survey, which was conducted in February 2013, had 686 respondents living in the Groningen earthquake region, and contained a range of questions including some specifically relating to anxiety, trust in the national government, and feelings about safety (DvhN and Enigma Research, 2013).

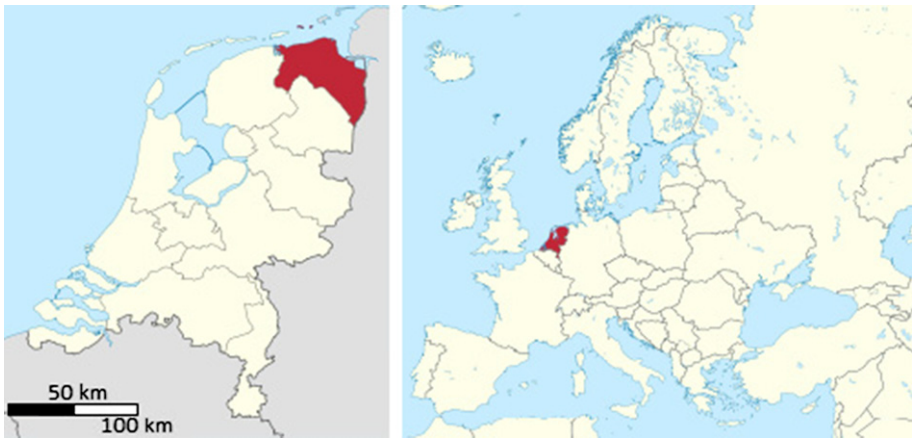
Although we have not done formal research interviews for this project, mindful of research ethics (Vanclay et al., 2013) and consistent with how social impact assessments are often done (Baines et al., 2013), various discussions about the earthquake issue with a range of people in various agencies and with some local residents have generated insights we also utilise in our thinking and analysis.

An overview of gas extraction in the Northern Netherlands

NAM, a 50:50 joint venture between Royal Dutch Shell (Shell) and ExxonMobil, established an exploratory gas well at Slochteren, in the Province of Groningen, The Netherlands, in 1959. This gasfield has since proved to be one of the largest in the world, and is now known as the Groningen gasfield (NAM, 2013a). With commercial production commencing in 1963 (NAMPlatform, 2013a), the Groningen gasfield has become very important for the Dutch economy and domestic energy supply. In 2012, NAM produced a total of 59.6 billion m^3 gas, representing 76% of total Dutch gas production, with some 88% of NAM's production coming from the Groningen gasfield (i.e. about 52.4 billion m^3) (Ministry of Economic Affairs, 2013; NAM, 2013b). Because of various import and export arrangements, it is not clear which part of Dutch or Groningen production is used strictly for domestic consumption. However, it is known that total Dutch domestic gas demand in 2012 was approximately 43.6 billion m^3 (Centraal Bureau voor de Statistiek, 2014), thus the production volume from the Groningen gasfield is about 20% more than total domestic consumption.

Groningen, 1 of the 12 provinces of The Netherlands, is located in the far north (Fig. 1). With a surface area of 2325 km^2, the province had 581,705 inhabitants in January 2013 (Centraal Bureau voor de Statistiek, 2013a). It consists of 23 municipalities, with the City of Groningen being the capital of the province.

The Groningen gasfield is located in the eastern part of the province (Fig. 2). The gasfield covers approximately 900 km^2 and it is now known that it contained 2800 billion m^3 of gas when production commenced. At the end of 2012, some 780 billion m^3 remained, arguably sufficient for another 50 years of production depending on the rate of extraction (NAM, 2013b). The gasfield covers approximately 39% of the land area of Groningen. Around 190,000 people live within the gasfield (Centraal Bureau voor de Statistiek, 2013a). The gas is located approximately 3 km below the surface in a porous layer of sandstone. When the gas is extracted, the sandstone compresses. Usually this is a gradual process leading to surface subsidence, which is barely noticeable and not generally regarded as being problematic. Along fault lines, however, it is now accepted that the movement of the sandstone layers can happen quickly, causing minor earthquakes (Deltares, 2011).



Source: Wikimedia Commons (2011a), Wikimedia Commons (2011b).

Fig. 1. Groningen as part of The Netherlands and The Netherlands as part of Europe. Source: Wikimedia Commons (2011a), Wikimedia Commons (2011b).

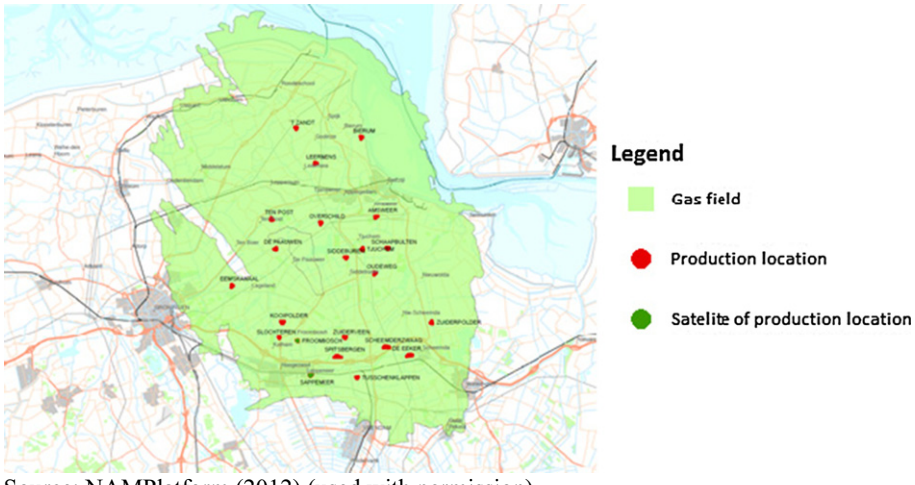
The Royal Netherlands Meteorological Institute (KNMI), which is responsible for registering earthquakes in The Netherlands, has constructed a map showing the earthquakes registered in the region surrounding the Groningen field (Fig. 3). The dots show the location and magnitude of the earthquakes. The larger the dot, the greater the magnitude. As can be clearly seen, the earthquakes do not occur in all areas of the gasfield, but are concentrated in the northwestern and southern parts, where there is a concentration of fault lines (Van Eck et al., 2006). Around 60,000 people live in this critical area known as the earthquake zone (Centraal Bureau voor de Statistiek, 2013a).

Stakeholders involved in the gas extraction

The Dutch national government plays a key role in gas extraction. The Mining Act of 2002 states that all minerals, gases and oils in the ground belong to the State. Any company can apply for an exploration licence. When a company establishes there is a commercially-viable reserve, it applies to the national government for a production licence (Overheid.nl, 2013a). The extracted resources become the property of the company upon payment of appropriate royalties and other arrangements that the State might determine (Overheid.nl, 2013b). For the Groningen gasfield, the State is intricately involved (see Fig. 4), as will be explained below.

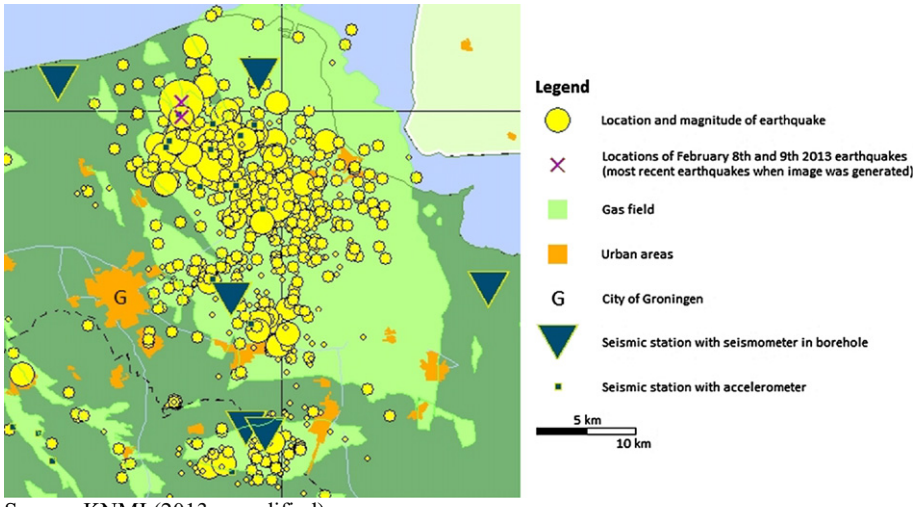
NAM is jointly owned by Shell and ExxonMobil, each with a 50% holding. *Maatschap Groningen* (Partnership Groningen) is a partnership between NAM having a 60% shareholding and *Energie Beheer Nederland* (EBN) with 40% (Tweede Kamer, 2007). EBN is a state company which the State uses to participate financially in oil and gas activities. The Mining Act obliges the licence holder to enter into a partnership with the State once a production licence has been issued. In the case of NAM, 40% of the extracted gas is transferred to EBN. EBN also contributes 40% of the extraction costs. Thus, in theory, EBN could potentially experience losses (EBN, 2011, 2013; Overheid.nl, 2013b). As the technical partner in *Maatschap Groningen*, NAM is responsible for actual extraction. *Maatschap Groningen*, however, is involved in the decision about how much gas should be extracted (Overheid.nl, 2003; Tweede Kamer, 1999). Despite the 60:40 share division, both partners are equal in terms of policy management (Overheid.nl, 2003).

Each party can utilise their proportion of the gas as they determine (Overheid.nl, 2013b). In actuality, however, all the gas is sold by *Maatschap Groningen* to a sole buyer, GasTerra, for an agreed price (Overheid.nl, 2003; Tweede Kamer, 2000). GasTerra is a joint venture comprising the State (10%), EBN (40%), Shell (25%) and Esso (a subsidiary company of ExxonMobil) (25%) (GasTerra, 2013a). GasTerra sells the gas to domestic energy retail companies and a few large domestic industrial consumers or exports it to international customers, generating sales revenues (Fig. 5). GasTerra also imports gas to manage



Source: NAMPlatform (2012) (used with permission).

Fig. 2. The Groningen gasfield. Source: NAMPlatform (2012) (used with permission).



Source: KNMI (2013c, modified).

Fig. 3. Earthquakes registered from 1990 up to 21 February 2013. Source: KNMI (2013c, modified).

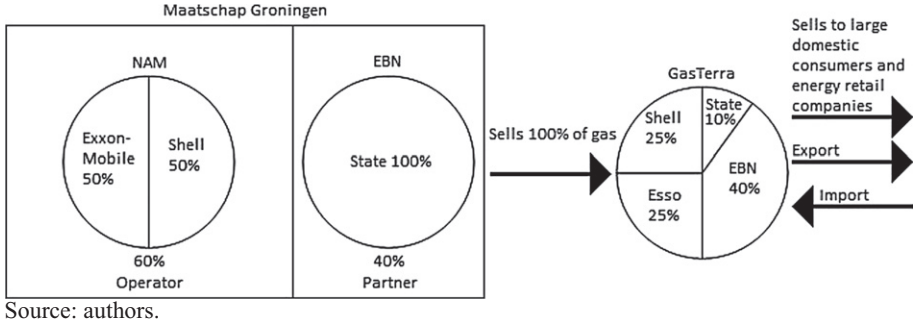
shortfalls in supply and because of the specific needs of some customers with particular specifications (GasTerra, 2013b).

Gasunie is the entity responsible for transporting gas. Gasunie is a 100% state company that owns the gas distribution rights and pipeline infrastructure in The Netherlands (Gasunie, 2013a,b). The amount GasTerra pays Gasunie each year is not readily available, although GasTerra's annual report reveals that its total transportation costs in 2012 were €506 million. However, this includes not separately-identifiable payments to pipeline owners in other countries (e.g. Germany and the UK). The national government has fixed the annual maximum profit (i.e. total dividend distribution) of GasTerra at €36 million (EBN, 2006), which is split pro rata among its shareholders (GasTerra, 2013c). Any amount in excess of this maximum is transferred to *Maatschap Groningen* by manipulating the price GasTerra pays for gas (Tweede Kamer, 2000).

As the licence holder, NAM pays a royalty to the State, which in the Groningen case is around 7.6% of sales revenue, but varies slightly according to the level of production (Overheid.nl, 2013b). In addition to the royalties paid and the money that flows to the State through EBN, the State also demands a profit share from NAM. On top of company tax (charged at 25% of profit, the normal company tax rate in The Netherlands), the State also requires that NAM pays a profit share of approximately 50% of profit after tax (the exact calculations are quite complex) (Nederlands Olie- en Gasportaal, 2012). The Dutch State also imposes an annual 'area fee' based on the surface area of the territory the production licence covers, which for the Groningen gasfield is 2970 km^2 (Taverne, 2001). In 2013, the area fee was €725/km^2, thus totalling €2,153,250 (Overheid.nl, 2013b). NAM also pays all other local government rates, water board charges, and service provider fees on its properties, the same as any other landowner or business.

Although there appears to be a myriad of companies, joint ventures and actors involved in gas production, when examined closely, there are only three main actors: the State, ExxonMobil/Esso and Shell. Since the two commercial partners communicate as a single entity, effectively there are only two actors: the State and NAM. Although their primary mutual interest is to produce as much gas and hence income as possible, to ensure longevity the national government has implemented a production cap system. For the Groningen gasfield for the period of 2011 to 2020, it has stipulated a maximum extraction of 425 billion m^3 with an additional 20.7 billion m^3 surplus carried forward from the previous period—in other words, an average annual extraction of approximately 45 billion m^3 (Ministry of Economic Affairs, 2013). In 2013, 53.8 billion m^3 was produced (RTVNoord, 2014a).

From the analysis above, it is clear that the State collects revenue from multiple sources due to its involvement throughout the production process. It earns money from the sale of gas; it has a share in the profits of NAM; it earns money from royalties, taxes and fees; and from dividends. In 2011, the total income to the Dutch State from all gasfields in The Netherlands was €12.4 billion, comprising 4.5% of all national government income (Centraal Bureau voor de Statistiek, 2012). More than €10 billion comes from the Groningen gasfield alone (Kamp, 2014). The State typically collects around 70% of all the profit made from gas extraction (Tweede Kamer, 2008). However, an agreement between the State and NAM specifies that when the gas price rises above a certain level, the State's percentage increases, such that the total income to the State can be in the vicinity of 85–95% of all profit



Source: authors.

Fig. 4. The actors involved in Groningen gas production. Source: authors.

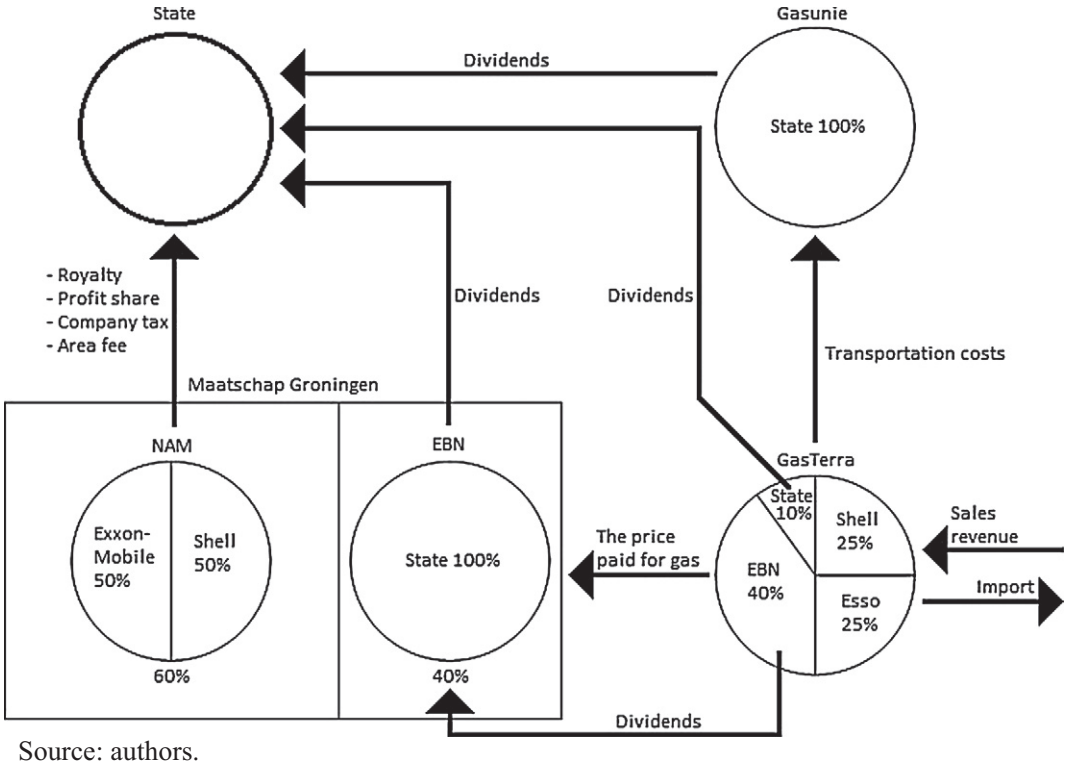


Fig. 5. The actors involved in gas production and money flows. Source: authors.

(Tweede Kamer, 2008). It is understood that this was the case at the time of writing and has been so for the past several years. A '91–9 split' (with 91% going to the State and 9% to NAM) was a remark mentioned by some people with whom we spoke.

The national government thus has a strong financial interest in continuing gas extraction, especially in this post global financial crisis period when other revenues have been reduced. The interest however does not extend to the Groningen provincial government. According to the 2002 Mining Act, the Province in which a production site is located receives a once-off payment on commencement of drilling. For a new production site, in 2013 that amount would be around €5.45/m^2 of drilling site surface area (Overheid.nl, 2013b). However, production in Groningen commenced before the implementation of this fee, and as best as we can determine, the Province of Groningen received no initial payment and has not received nor currently receives any direct financial benefit from gas production. Arguably there are indirect benefits in the form of economic regional multiplier effects arising from the headquarters of Gasunie and GasTerra being located in Groningen, and NAM in nearby Assen in the province of Drenthe. Gasunie, GasTerra and NAM also have a range of sponsorship arrangements. For example, GasTerra is highly associated with the local basketball team (the GasTerra Flames), and in 1987 Gasunie donated 25 million guilders (about €11.3 million) towards the construction of the Groninger Museum. In general, however, there is little commitment by these companies to local social investment (Esteves and Vanclay, 2009; van der Ploeg and Vanclay, 2013), perhaps on account of the large amount they already pay to the national government.

The Province did receive some funding from the Fund for Economic Structure Reinforcement (*Fonds Economische Structuurversterking*, FES). Its goal was to finance projects that strengthen the economic structure of The Netherlands. A proportion of the money the State earned from gas production formed the income stream for the FES (Algemene Rekenkamer, 2011). Much concern arose because it was established that the three northern provinces collectively received only 1% of the total funds made available through the FES even though they accounted for 10% of the Dutch population—the remaining 99% having been distributed amongst the nine other provinces (Instituut voor Onderzoek van Overheidsuitgaven, 2006). In 2011, the national government abolished the FES in response to criticism of the way the Fund allocated funding and its effectiveness (Tweede Kamer, 2010). The income stream to the Fund was diverted back to the State treasury (Algemene Rekenkamer, 2011).

This lack of financial interest in gas production means that the Province of Groningen's only role is to ensure the safety and wellbeing of its citizens (Provincial Executive of Groningen, 2013a), and it therefore is widely trusted by its citizens. In contrast, the national government is perceived to have a conflict of interest. Some 75% of respondents in the RegioNoordPanel survey thought that the national government did not prioritize the interests of the Groningen people in decisions about gas production (DvhN and Enigma Research, 2013). With declining trust in the national government, they turn to local and regional governments which tend to support their cause.

Distrust in the national government led to some inhabitants establishing a community association, the Groningen Ground Movement (GBB or *Groninger Bodem Beweging*), to ensure their voices were heard. GBB aims to help people impacted by gas extraction. It helps people in preparing claims for damage and provides information. It also advocates on behalf of residents by talking to the media and politicians (GBB, 2013a). After the SodM report was released in January 2013, GBB's membership doubled to 670 (RTLNieuws, 2013a). By January 2014, membership had reached 1600 (GBB, 2014). There are a number of other small local action groups, but these are less influential.

A short history of earthquakes in the Northern Netherlands

Gas extraction is typically accompanied by subsidence. It is estimated that over time subsidence has lowered the surface by up to 30 cm—as in the village of Loppersum, the most severe case (Deltares, 2011). Predictions are that by 2070, subsidence will increase by up to 47 cm below pre-extraction levels. However, because the subsidence is gradual and

over a wide area, little to no damage to buildings or other impact was expected to occur (Deltares, 2011), other than a predictable effect on surface water flow and drainage which would be managed by a range of engineering measures.

A significant problem that has emerged, however, is earthquakes. Before 1986, no earthquakes had been officially registered, although it is generally accepted that minor earthquakes occurred in 1976, 1981 and 1984 (Leeuwarder Courant, 1988). The first officially-registered earthquake occurred in December 1986 in Assen, in the Province of Drenthe, to the south of Groningen (KNMI, 2013a). Dr. Meent van der Sluis, a social geographer and member of the Drenthe provincial council at the time, conjectured that the earthquakes were linked to gas production. NAM described his theory as being 'laughable', denigrated him by saying he was 'a geographer, not a geologist', and stated that 'if there is one company that knows about faults and gas production, it is NAM' (Nederlands Dagblad, 1988). The Royal Netherlands Meteorological Institute (KNMI), which is also the national centre for seismology, backed NAM by stating it was 'impossible' for his theory to be true (De Telegraaf, 1994). In 1990, the Province of Groningen asked two geophysicists from Boston's MIT to assess the risks associated with subsidence. Given the controversy at the time, they also provided their view on the possibility of earthquakes stating that they thought the chances of significant tremors were very low. A worst case scenario, they suggested, would be the equivalent to the feeling of a truck passing by (DvhN, 2014a).

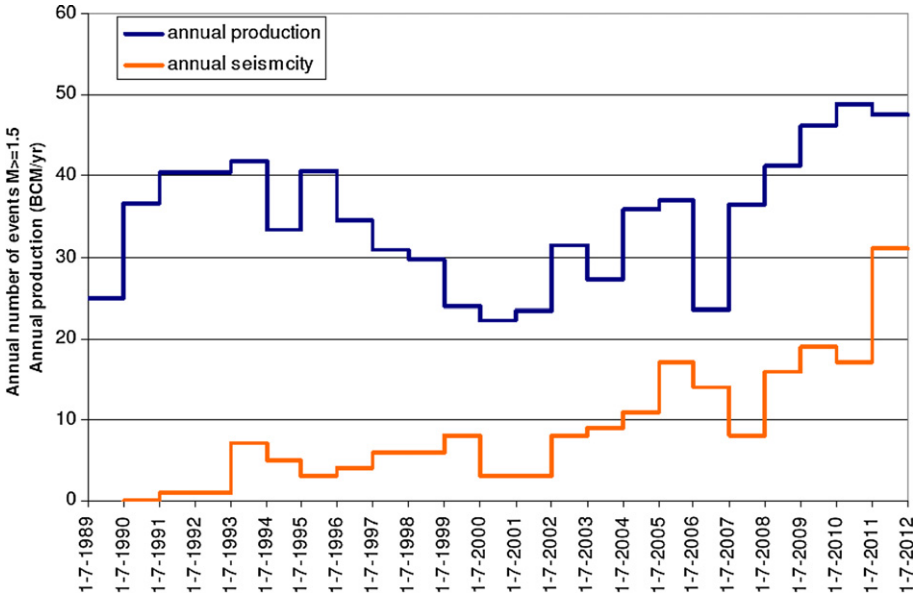
Over the years, the frequency of earthquakes increased, eventually attracting the attention of Parliament, which decided in 1991 to establish a commission to investigate (Leeuwarder Courant, 1992, 1993). The commission concluded in 1993 that earthquakes can be caused by gas production in certain circumstances (KNMI, 2013d). NAM subsequently admitted the link between earthquakes and gas production (De Telegraaf, 2013). However, they continued to refuse to pay for damage until 1997, stating that earthquakes with a magnitude of less than 3.3 could not cause structural damage. Residents had to prove otherwise if they wanted to be compensated (De Telegraaf, 1994; DvhN, 2014a). At the time, the magnitude of the highest registered earthquake in the northern Netherlands was 2.8 (KNMI, 2013b).

In February 1997, a 3.4 earthquake occurred near Roswinkel, in the Province of Drenthe. At the time, it was the largest induced earthquake ever recorded in The Netherlands. Research by KNMI at that time had suggested that magnitude 3.4 would be the largest earthquake likely to be expected (De Crook, 1996). The 1997 earthquake thus caused KNMI to reconsider their predictions. Using a Monte Carlo simulation and based on earthquakes up to 1997, KNMI calculated, with a certainty of 85%, that the new likely maximum magnitude would be 3.8 (KNMI, 1998).

The unexpectedness of the severity of the August 2012 earthquake in Huizinge (magnitude 3.6) led to the commissioning by the Ministry of Economic Affairs of 15 studies on a range of topics. As previously indicated, in January 2013, SodM submitted one of these reports. Its key message was that the increase in gas production between 2000 and 2013 had undoubtedly led to more frequent and stronger earthquakes (Fig. 6). They warned that if gas extraction continued at the current rate, there would be a 7% chance of an earthquake with a magnitude of between 4.0 and 5.0 in the next 12 months (SodM, 2013). There was also a small chance of an earthquake with an even higher magnitude. This pronouncement sent a political shockwave around the country.

The Province of Groningen stated it was not satisfied with the overall perspective and framing of the suite of 15 studies. The Provincial Government considered that more attention should be given to the future of the province and it therefore established its own inquiry, the Commission for a Sustainable Future in North-Eastern Groningen, which published its report (the Meijer Report) in November 2013 (Commissie Duurzame Toekomst Noord-Oost Groningen, 2013). The report concluded there was an imbalance in the distribution of advantages and disadvantage from gas production. It argued that: the national government should acknowledge that it not only has rights but that it also has duties to protect the people; and that the national government should ensure the area can continue to develop sustainably, which, according to the committee, was not currently the case. Finally, it recommended that NAM should publicly accept that gas production cannot continue in the current manner.

The SodM report prompted much concern and public discussion about the issue. The Minister of Economic Affairs was kept very busy, but he tended to be defensive in his response to the issue, often highlighting the economic benefits of gas extraction. In November 2013, the Netherlands Institute for Human Rights (College voor de



Source: SodM (2013) (note that the typo is in the original) (used with permission).

Fig. 6. Annual production and annual seismicity compared. Source: SodM (2013) (note that the typo is in the original) (used with permission).

rechten van de mens, 2013) saw fit to write to the Minister to remind him that the issue was not just an economic one, that there were serious social and human rights impacts experienced by the residents, and that the State had a positive duty to address these issues. The Institute also wrote to the Dutch Safety Board (*Onderzoeksraad Voor Veiligheid*) to urge them to take a human rights framework in their assessment of the safety of people living in the earthquake zone (College voor de rechten van de mens, 2014).

The social impacts caused by the earthquakes

Following publication of the SodM report, the earthquakes received much attention in the local, national and international media (e.g. BBC, 2013; New York Times, 2013). Many newspapers and television programs interviewed local people about their fears, perceptions and experiences of the impacts of the earthquakes. The regional media, specifically RTVNoord (the regional Groningen public television broadcaster) and *Dagblad van het Noorden* (DvhN) (the regional daily newspaper) were particularly interested in the topic. In February 2013, DvhN commissioned the market research panel, RegioNoordPanel, to consider a range of questions, around topics such as anxiety, trust in the national government, and feelings about safety (DvhN and Enigma Research, 2013). From our analysis of media reports about the earthquake issue, our own analysis of the RegioNoordPanel survey data (provided by Enigma Research), and our understanding of social impact issues generally (Langbroek and Vanclay, 2012; Vanclay, 2002, 2003, 2014; Vanclay and Esteves, 2011; Vanclay et al., 2013), we outline the social impacts experienced. The topics that emerged from our analysis included: damage to property; decline in house prices; concern about the chance of dykes breaking; feelings of insecurity; health issues; and increased distrust and anger.

It is worth noting that impacts can be categorised into first, second and higher order impacts. The first order impacts of the gas extraction are earthquakes and subsidence. These cause second order impacts, like damaged buildings and anxiety. Damaged buildings cause economic impacts, which are third order impacts, which in turn lead to more social impacts in the form of even more anxiety and stress. It is also important to appreciate that impacts are differentially distributed in a community—men and women experience things differently, older people are often more vulnerable to the anxiety and harm associated with impacts, and people on low incomes and/or high mortgages may be particularly affected (Vanclay, 2002, 2012).

Damage to property

The cumulative earthquakes have caused damage to houses, for example wall tiles have become loose, cracks have appeared in walls and beams, and with damage to roofs, buildings have become susceptible to rainwater intrusion (DvhN, 2013c; RTVNoord, 2013a). The projected heavier earthquakes will cause even more damage. For example, the results of a damage prediction study (another of the 15 commissioned studies) concluded that an earthquake of magnitude 5.0 would lead to around 10 houses being very severely damaged with perhaps a few houses collapsing (Arup, 2013).

Between August 2012 (when NAM started publishing the numbers of claims received) and July 2014 (the most up-to-date data before publication of this paper), 19,712 damage claims had been submitted to NAM (NAMPlatform, 2014a). By the end 2013, NAM had completed assessing around 4700 damage claims, totalling over €50 million (NRC, 2013b). A total damage estimate of over €200 million can be reasonably estimated for damages sustained up until 2014, but with more earthquakes likely, the final amount over the next 10 years or so could be many times this.

In addition to the direct damage to buildings, there will likely be consequent social impacts. For example, damaged commercial or farm buildings may become unusable, leading to lost business. People may need to take time off work in order to be at home to meet the damage consultants and/or the repair tradespeople. These indirect costs are not compensated by NAM. There is also the issue of damage to cultural heritage. There are 1296 heritage-listed buildings and sites in the earthquake region (DvhN, 2013d). In 2013 NAM established that 350 of the received damage claims related to heritage-listed buildings, i.e. around 27% all heritage listings in the earthquake region (DvhN, 2013e).

Decline in house prices

As a result of the immediate physical damage, the value of buildings was affected. However, the reduced attractiveness of the area also impacts on property prices (Vanclay, 2012). Some 41% of the RegioNoordPanel survey respondents expected that the value of their house would decrease. In Loppersum and surroundings, the municipality that is most severely affected by earthquakes, 69% expected a reduction in house price (DvhN and Enigma Research, 2013). Some people fear they will not be able to sell their house at all (DvhN, 2013c). Real estate brokers share these fears (DvhN, 2013f).

In a declining region such as the northern Netherlands (Bijker et al., 2013; Haartsen and Venhorst, 2010), independent of the earthquakes there is pressure on housing prices, especially in the aftermath of the 2008 global financial crisis (Centraal Bureau voor de Statistiek, 2013b). As another of the 15 studies, ORTEC Finance (2013a, 2013b, 2014a, 2014b) assessed whether house prices in the region had declined significantly more in the earthquake region than in two matched reference areas. The results were initially inconclusive, with GBB questioning the objectivity of ORTEC Finance and the methodology used (GBB, 2013b). There has since been widespread acceptance that a devaluation of house prices has occurred and a compensation scheme has commenced (discussed later).

Concern about the chance of dykes (levee banks) breaking

Bert Middel, the chairman of the water board, Noordzijlvest, which partly covers the Groningen-field, said in a radio interview (Radio 1, 2013) that a strong earthquake could damage dykes, which would lead to major flooding, and therefore action was needed to strengthen the dykes. The dykes of particular concern were alongside the Eems canal, which runs across Groningen, through the area of high earthquake risk. Middel said that if a dyke on one side of a canal would break, there was a high likelihood that the dyke on the other side of the canal would also break (due to the currents created). He then said that since the surrounding land area is approximately 2.0 m lower than the normal water level, a large area could be flooded and gas production might be affected. In a worst case scenario, this could affect the distribution of gas in The Netherlands.

This issue was investigated by the consultancy firm, Deltares. It concluded that a magnitude 5 earthquake could cause significant damage to dykes that meet the current technical specifications for dykes, but the chance of major flooding was limited (Deltares, 2013). However, the risk of damage and flooding increased in locations where the dykes were sub-standard. The Provincial Executive of Groningen (2013b) has established that 44% of the dykes in the Groningen gasfield region did not meet current technical specifications. Significant investment will be needed to ensure all dykes are improved to meet or exceed the current standards.

Although Bert Middel received much publicity and has repeated his concerns often, and there is evidence that some people were concerned about this issue, the majority of residents were more concerned about the risks to the buildings in their immediate vicinity. Nevertheless, while the risk of dykes breaking might not be an immediate concern of most people, the issue is likely to be a background concern adding to the general feeling of unease and uncertainty.

Feelings of insecurity

The publication of the SodM report was an impact in itself with people becoming more anxious about what will happen to them. An exacerbating effect was that in the weeks following publication of the report, several earthquakes occurred, some of which were the most severe in many years (KNMI, 2013b). This increased the levels of anger and anxiety. Over the last 20 years, several studies have been done to establish the maximum likely magnitude of an earthquake. Every new study concluded that an earthquake with a higher magnitude than previously assumed was possible. This added further to the feeling of insecurity and distrust.

Damage to property, especially in visible, vital spots like walls and beams, can lead to a feeling of insecurity in one's own home. The uncertain risks to dykes also contribute to this feeling. Fear and anxiety are amongst the more important social impacts a project can have (Vanclay, 2012). Since home is meant to be 'a safe haven', a feeling of insecurity in one's own home is a particularly significant social impact. In the context of all the hype around possible stronger earthquakes, the visibility of cracks reinforces the feeling of potential danger. Delays in getting the cracks fixed has considerable social and emotional impact, much more than would be suggested by technical assessments.

These issues were revealed in the RegioNoordPanel survey. People living in Loppersum gave their safety an average rating of only 5.8 out of 10 (compared to 6.3 for the RegioNoordPanel as a whole), in response to the question: 'On a scale from 0 to 10, indicate how safe you feel in relation to earthquakes' (DvhN and Enigma Research, 2013). Unfortunately, a true comparative benchmark for this question, say for the Netherlands as a whole, is not available, but at face value 5.8 (and 6.3) would appear to be low. People reported that the knowledge a heavier earthquake may occur leads to a feeling of discomfort. Continually talking about it also makes it worse (DvhN, 2013g; New York Times, 2013; RTVNoord, 2013b). Also, the uncertainty about the likely severity of future earthquakes makes people uncomfortable (De Telegraaf, 2013; RTVNoord, 2013c).

Health issues

The feeling of insecurity can lead to various health problems. Health is defined in the World Health Organization (1946) as 'a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity' (Vanclay, 2003, p. 8). Some 15% of the respondents of the RegioNoordPanel claimed to have various health issues related to the earthquakes, including stress, anxiety, insomnia and depression (DvhN and Enigma Research, 2013). Among other things, the extent of media attention and continuously having to talk about the earthquakes lead to feelings of discomfort and unease. When this is experienced for any extent of time, it leads to a range of mental and physical ailments (Wilkinson and Marmot, 2003). Besides these mental health issues, physical health issues may also arise. Should part of a building collapse on top of someone, or if a dyke would break, people could be injured and fatalities are possible (DvhN, 2013h). Even a slight tremor can cause injury or death if something heavy or pointed were to fall on a person, say from the top of a high bookshelf.

Increased distrust and anger

Publication of the SodM report led to a media frenzy. While this media interest has ultimately led to action in addressing the issues, it also caused considerable angst and resentment. Not only did residents have to deal with their own concerns about the earthquakes, they had to cope with large numbers of reporters, photographers, voyeurs, and researchers. Just going to the local shop in the nearby village could mean having to 'run the gauntlet' of journalists. This was an impact and an intrusion in itself, but it amplified the other issues. Often people felt hounded and they became angry as a result of the media exposure.

The SodM report also affected NAM. Groningen people were already wary of the gas production and NAM was unpopular for various reasons (DvhN, 2013b), but since the SodM report, this deteriorated, having a negative effect on NAM's social licence to operate (i.e. their level of public acceptability). The King's Commissioner (i.e. provincial governor), Max van den Berg, spoke of a 'breach of trust' (RTVNoord, 2013d). Distrust is not an immediate direct effect of the earthquakes. It is partly based on the previous experiences of people and greatly influences and is influenced by the process of mitigation (DvhN, 2013b; João et al., 2011; Prenzel and Vanclay, 2014; Vanclay, 2012). This distrust derives partly from the lack of communication from NAM (DvhN, 2013i). Only 4% of the respondents of the RegioNoordPanel felt that NAM had informed them properly about gas production and its consequences (DvhN and Enigma Research, 2013). When production at a smaller field nearby in Veendam started, the people there also felt uninformed, especially because the local newspaper announced that the permit to NAM had been granted 8 months earlier. They felt that NAM should have announced their intentions clearly to the people directly. Although there was a briefing by NAM, the inhabitants felt it was far too little, too late (DvhN, 2013j; RTVNoord, 2013e). Even the managing director of NAM admitted that their communication was not sufficient (De Telegraaf, 2013).

Another source of distrust and anger relates to NAM's previous denials of the link between gas extraction and earthquakes, and their denial of the impacts of the earthquakes. How NAM reacted to previous earthquakes is also relevant. Making comments such as 'laughable', and NAM's stubbornness in not compensating for damage sustained in the 1990s, has contributed to the distrust. When the earthquakes became stronger than expected, people lost further trust in NAM (De Volkskrant, 2012). The ongoing increases in the projected maximum magnitude of the likely earthquakes has led to further suspicion (RTVNoord, 2013f). Distrust also derives from the way NAM attempts to mitigate the impacts and it undermines the effectiveness of mitigation efforts. In the 2000s, for example, the independent damage consultants thought they did a good job when their damage assessments (cost of repair) were as low as possible (DvhN, 2014a). NAM's mitigation efforts are discussed further in the next section.

The distrust also affects the national government. While GBB used to have to try to convince local people of its cause to get members, now GBB is inundated with members but has to convince them that talking to politicians is worthwhile (DvhN, 2013i). People wonder if they are being taken seriously by the national government (DvhN, 2014b). The opposition parties in the national parliament feel that the national government should do more for Groningen, as does the Mayor of Loppersum (DvhN, 2013i; RTVNoord, 2013g). As mentioned earlier, distrust towards the national government has led people to turn to the provincial government, which supports the cause of the inhabitants and takes a stance against the national government. People feel betrayed by their national government which they feel has pursued its economic interests over its responsibility to protect the people. They feel their interests have been ignored.

Another concern of residents that leads to anger is that no 'sorry' has been said. While the government and NAM are attempting to address many issues, they are reluctant to make a public apology, perhaps for fear of admitting liability. Nevertheless, for many people who have been affected by the earthquakes over a long time—in many cases before it was accepted that the earthquakes were caused by gas extraction, and in some cases before it was even accepted that there were earthquakes—the lack of a public apology is in itself an issue causing resentment.

This analysis of the situation is a classic example of how the importance of 'good process' is underestimated. Vanclay (2012) considers that 'process is everything' and that non-genuine community engagement can increase fear and anxiety. 'Good social process reduces social impact, poor process creates concern and fear and anxiety' (Vanclay, 2012, p. 152), exactly what has happened in Groningen.

The disadvantages of gas production have been underestimated for a long time and have turned out to be worse than predicted. As with an over-estimation of benefits, an under-estimation of the disadvantages can also lead a community to 'feel cheated and deceived, lowering their trust in the proponent and regulatory bodies' (Vanclay, 2012, p. 153). Previous negative experiences (the impact history) influence people's opinions of current projects, even when projects might be beneficial (Vanclay, 2012). The lack of trust and low trustworthiness of proponents lead to increased fear and anxiety. In the Groningen case, there is a widespread perception that the benefits go to the nation as a whole and there is little benefit to local people. Now with the risk of personal harm and significant loss to property and prospects, many people feel outraged (Kamp, 2014).

Mitigation efforts

The social impacts discussed above have led (and will likely continue to lead) to a loss in NAM's social licence to operate amongst some people in the region. In the RegioNoordPanel survey, 42% of participants said they were willing to protest against continued gas extraction. The most frequently-mentioned actions respondents indicated they would consider taking included collectively stopping paying their gas bills, and mass protests in The Hague (the seat of national government and the headquarters of Shell) or at the NAM office in nearby Assen. Some 23% would consider occupying a production site or blocking access to production sites (DvhN and Enigma Research, 2013; RTVNoord, 2013e). Effective mitigation by NAM may recover some of their social licence and increase the wellbeing of Groningen inhabitants.

A popular measure anticipated to reduce the number and intensity of the earthquakes would be to drastically reduce gas production, as SodM recommended (SodM, 2013). However, not all experts agree this would help, at least in the short term, because differential pressure gradients and a lag effect mean that earthquakes are likely to continue for some time even if production is completely stopped (De Telegraaf, 2013; DvhN, 2013k). These contradictions between public common sense and expert opinion, and disagreement between experts, lead to much uncertainty among the inhabitants. In February 2013, the Minister of Economic Affairs indicated he was reluctant to decrease gas production although he would take action if needed (NRC, 2013a). Reducing gas production would create difficulties in terms of honouring existing supply contracts and would require additional gas imports, which would introduce various technical complications given that the imported gas has a higher calorific value than Groningen gas (NOS, 2013a). The Minister said he would wait for a report from a new geomechanical investigation being done by NAM before taking action (Kamp, 2013a). This investigation is a massive modelling exercise likely to take several years. The information it will provide was not previously available and will be technically superior to the evidence used by SodM (Provincial Executive of Groningen, 2013a; SodM, 2013). Although undertaken by NAM, the investigation has the oversight of some independent experts. The study will inform a revised gas exploitation plan NAM must submit to SodM for assessment. Even with the oversight of independent experts, the inhabitants of Groningen are likely to be wary of the report's findings because it is being done by NAM to justify their ongoing production.

Given the strong interest of the Dutch State in maintaining production, it is unlikely that gas production will be stopped or greatly decreased in the near future. Therefore, in this section we investigate how the previously-described impacts can and are being mitigated, assuming gas production remains at levels comparable with current quotas. The various mitigation measures that are being used are evaluated. Likely residual impacts are also considered.

Damage to property and concern about compensation mechanisms

When a house is damaged by an earthquake, the homeowner reports the damage to NAM. A NAM liaison officer is assigned to assist the homeowner in the compensation process. An independent damage assessor determines the extent of damage and estimates the cost of restoration. A building contractor is then asked to provide a quotation. If the home owner agrees with these assessments, the next steps for restoration and compensation are discussed. If a homeowner does not agree with the assessments, they can request a second opinion from another party, at NAM's expense. If NAM disagrees with the second opinion, the two damage consultants are asked to negotiate their differences. If this does not lead to an agreement, a third damage consultant will be asked to adjudicate. Where the homeowner remains dissatisfied, they can ask a special committee to consider the case. When the damage is assessed and all parties agree, a building contractor is engaged to undertake the restoration, paid for by NAM (NAMPlatform, 2013b). In one instance to date, the damage was so severe that NAM decided to buy the house (DvhN, 2013l).

Many people complain about this damage compensation procedure suggesting it is too much hassle to obtain appraisers and contractors (RTVNoord, 2013b). Of people in the RegioNoordPanel whose compensation procedure had been completed, 47% were unsatisfied or very unsatisfied, with only 28% being satisfied or very satisfied (DvhN and Enigma Research, 2013). NAM and the damage consultants are said to be stubborn (DvhN, 2014b). LTO Noord claims that farmers 'have to fight' to get compensation (RTVNoord, 2013h). The average length of time taken to complete an assessment (i.e. before actual restoration) is 5–7 months (NAMPlatform, 2014a), which is deemed to be excessive by those who are affected. This delay can also lead to unsafe situations, with damaged houses being more susceptible to further damage should there be another earthquake. With the extent of damage in Groningen (over 19,000 damage claims), there are long waiting times for tradespeople.

More severe earthquakes in the future will increase the number of properties damaged and the extent of damage to each property, which will further lengthen the compensation procedures. More damage and longer waiting times will be bad for the already fragile image of NAM. Therefore, on a number of occasions it has promised to develop a more efficient compensation procedure (De Volkskrant, 2013; RTVNoord, 2012a, 2013i). NAM also tries to improve the way it assists people through the process by establishing an information office in the Loppersum City Hall where NAM staff help people fill in claim forms (NOS, 2013b; RTLNieuws, 2013b). NAM also indicated that previously-declined compensation claims would be reconsidered if they were re-presented, an action initiated by NAM partly in response to threatened legal action (RTVNoord, 2013j). Another measure NAM announced it would take is to employ more staff to undertake the appraisals (De Volkskrant, 2013). This should at least partly mitigate some of the impacts of the compensation process.

Not only the length of the compensation procedure has been criticised, but the objectivity of the damage assessments has been questioned. NAM currently oversees the damage assessment process and wants to keep doing so (RTVNoord, 2012b). However, GBB (2013c) and some 84% of the respondents in the RegioNoordPanel would prefer to have an independent entity assess the damage compensation (DvhN and Enigma Research, 2013). This issue is interesting, because in the current process the damage consultants are actually from external, independent companies and overall only 3.2% of homeowners have asked for a second opinion (NAMPlatform, 2014a).

NAM has commissioned an investigation to consider the specific risks associated with different types of houses so that preventive measures can be identified and implemented, even though it is understood that houses cannot be made to be completely earthquake resistant (DvhN, 2013m). For this investigation, NAM will buy several undamaged houses to experiment with (DvhN, 2013n). It is anticipated that several thousand houses will need structural reinforcement (Arup, 2013). Unsafe situations will have highest priority for attention (DvhN, 2013o). In January 2013, NAM announced that it had created a fund of €100 million to pay for these measures (RTVNoord, 2013i).

However, GBB felt that this was far from adequate and inhabitants were concerned that NAM will manage this fund, preferring an independent entity to do this (NOS, 2013a).

The mitigation efforts regarding damage and compensation mechanisms are not adequate. The damage compensation process takes too long, increasing the frustration of inhabitants and potentially leading to unsafe situations. People are not satisfied with NAM being responsible for damage compensation, even though the assessments are done by external experts. To increase the efficiency and credibility of the process, it is recommended to employ more staff and to transfer responsibility for the damage compensation process to an independent party perceived to be legitimate by local residents.

Decline in house prices

There is debate about the validity of the ORTEC Finance research which initially concluded there was no significant decline in house prices as a consequence of the earthquakes. Regardless of this debate, 90% of the RegioNoordPanel felt there should be compensation for decreased property values (DvhN and Enigma Research, 2013). In July 2013, the Minister of Economic Affairs (Kamp, 2013b) suggested that where there was a demonstrable decline in property values due to the earthquakes, people may be eligible for compensation, and he would negotiate with NAM to establish an appropriate procedure. In January 2014, the Minister (Kamp, 2014) announced the details of the compensation scheme. It would be restricted to people who sold their house after 25 January 2013 (the day the SodM report was published) and live in one of eight municipalities designated as being earthquake affected (NAMPlatform, 2014b). The compensation would be based on the difference in the normal sale value of a house in the earthquake area compared to the value of a similar house in a comparison reference location. An appraiser will assess if a house had indeed suffered a decline in price. The appraiser would look at the state of the house and other circumstances specific to the house (Kamp, 2014; NAMPlatform, 2014c). The idea was to have a procedure that was fair to home owners, as well as safeguarding NAM from improper claims. From a social impact assessment perspective, determining an appropriate compensation amount and payment mechanism is complex because the decline in value will persist well into the future. It will be important to ensure that the compensation mechanism will not unduly encourage people to sell and leave their community prematurely.

Concern about the chance of dykes (levee banks) breaking

As mentioned earlier, some 44% of the dykes are determined to be sub-standard. Therefore, it is possible they could sustain damage from the earthquakes. The Province of Groningen has ordered the water boards to ensure the dykes are up to standard by 2020. Before then, however, there is a chance of a severe earthquake that could cause flooding. The existence of designated sacrifice areas, i.e. places where water can be diverted away from urban areas, should reduce the risk of flooding. However, these areas are not available everywhere (Provincial Executive of Groningen, 2013b). The media attention given to the instructions of the Province to ensure the dykes are fixed is likely to have neutralised any public concern generated by the media appearances of Bert Middel. Given that the dyke issue was not a front-of-mind concern, probably no further action is needed to address the social impacts associated with this issue.

Feelings of insecurity

The feelings of insecurity are hard to mitigate, especially if the underlying causes of these feelings are not properly addressed first. Even then, the feelings may persist. When fully implemented, mitigation measures taken to prevent or reduce the social impacts might reduce feelings of insecurity, but if NAM itself undertakes these actions, it is doubtful whether the feelings will be ameliorated. The deep distrust towards NAM will likely lead to the perception that NAM only does 'half the job', even in situations where they actually attempt to fully address an issue. Mitigation of the feelings of insecurity is dependent on the mitigation of other impacts: 'damage to property and concern about compensation mechanisms', 'concern about the chance of dykes breaking' and 'increased distrust and anger'. Trust building therefore is a key starting point.

Health issues

Health issues are a second order impact. Mental health issues derive from the feelings of insecurity and general unease, while physical health issues occur as result of damage to buildings as well as from the physical manifestations of stress. In addition to dealing with the expressed health issues (symptoms), the underlying causes need to be addressed. Mitigation of the mental health issues depends largely on mitigating the feelings of insecurity, which ultimately relies on the existence of sufficient trust. However, these issues may not be fully resolved. If, for whatever reason, feelings of insecurity persist, mental health issues will also persist. Given the situation in Groningen, the level of trust is unlikely to significantly improve in the short to medium term, which will continue to have an ongoing impact on the perceived effectiveness of any mitigation. Other than improving the trust base, the only way to reduce the health issues is to stop gas production altogether, which, in the longer term at least, will stop the earthquakes from occurring. Resettling people out of the region would remove earthquakes as being the direct source of their mental and physical health issues, but would introduce a whole new set of triggers for mental health concerns. Relocation brings about a loss of community, an uprooting of social networks, and unsatisfied social aspirations, which undermine mental and physical health (Petticrew et al., 2005).

Physical health issues can be partly mitigated by preventing damage in the first place, and by paying for any medical expenses. It is not expected that many people will be injured from the earthquakes, so such a mechanism is not likely to be costly. However, since the possibility of severe injury or fatalities cannot be ruled out (as falling objects within a house can occur even with a light earthquake), large compensation claims are possible. Because no one has been injured yet (as at February 2014), no mitigation of physical health issues has been necessary to date. Nevertheless, inevitably some physical injury will happen in the future. To the extent we can determine, there is no established procedure as to what the national government or NAM will do if people are injured. A procedure should be established as soon as possible. Promoting awareness of this procedure is likely to enhance trust, but also runs the risk of increasing panic if not done in a careful way.

Increased distrust and anger

NAM is aware of the distrust amongst Groningen inhabitants. The managing director has admitted that NAM did not adequately estimate the risks in the past (RTVNoord, 2013k). As part of an overall campaign to improve trust, NAM sent a letter to all residents in the area presenting measures it will take to improve the damage compensation service (De Volkskrant, 2013). In August 2012, NAM apologised for failing to properly address the issues and for being slow in making changes to improve their damage assessment and compensation policy and procedures (RTVNoord, 2012a).

NAM has tried to improve the way people are informed by establishing an information office and by providing more briefings (DvhN, 2013p). In the case of Veendam, however, the decision to start drilling had been made before any public consultation, thus alienating many people (DvhN, 2013j). This is not a good strategy and is contrary to NAM's stated intention of holding briefings, thus providing further evidence to people that NAM is not trustworthy. Another example of problems in NAM's community engagement strategy is that in January 2013,

the Mayor of Loppersum stated he did not know that the level of production in the municipality had increased over recent years (NOS, 2013a). In an attempt to improve their image, NAM organised a tour around a new production site and NAM Board members visited local people at home to talk with them (DvhN, 2013m,q).

Distrust of the national government is also a problem. To address this, in March 2013 Minister of Economic Affairs, Henk Kamp, promised to visit the region more often (RTVNoord, 2013l). Many other members of parliament have also visited the area (RTVNoord, 2013m). However, it is worth noting that elections were held in March 2014, and potentially much of the concern of the political parties related to their positioning in the polls prior to the election. There is however a noticeable change over time in the tone used in the parliamentary briefings tabled by the Minister.

The parliamentary opposition parties claim that most of their motions to help Groningen people are blocked by the government. The government's response is that the 15 studies that have been commissioned is sufficient action (RTVNoord, 2013g). Whether these and the other mitigation measures taken by Minister Kamp and NAM will work remains to be seen. The trust may be damaged too severely to be restored with small measures. People may feel that the improved damage compensation service should have been there in the first place, and a tour around a production site may be informative but does not solve the problem. It seems NAM wants to improve its image by working on its image (showing interest in people's problems, paying them a visit), rather than addressing the problems that lead to the negative image. It is not clear how effective this will be.

The Province has also tried to increase the level of trust the inhabitants have in the mitigation process. The Province has established a process of 'dialogue tables' (Van Geel and Wallage, 2014). Here, various stakeholders are represented, including some Municipalities, the Province, NAM, the State, SodM and GBB. These parties are meant to commit to finding solutions to the problems and implementing them. The process is intended to be a consensual, deliberative process which is supposed to lead to solutions that are durable in the long term, and will increase trust. However, as at July 2014, the process seems to be bogged down, with dissatisfaction about the costs of the dialogue and the process itself.

Trust is hard to gain, but easy to lose (Vanclay, 2012). NAM and the government will need to be generous in their mitigation efforts. There have been many promises of improvement, yet many procedures are still not acceptable. While there may be a sense of urgency in NAM and the national government, at the community level it appears there is only an incremental approach to addressing the problem. Kapelus et al. (2011) provide many appropriate suggestions to ensure trust is sustainable. It is very important that NAM monitors what happens in the local communities and considers what decisions it makes and how these may increase conflict or concern. These decisions should then be adapted to avoid conflict (Prenzel and Vanclay, 2014). This should be done in a transparent and accessible fashion. People need to know what future steps NAM will take and how they will be implemented. This ensures new steps don't come as shock, otherwise it may lead to more venting and conflict.

Conclusion

With high gas prices and the considerable financial interest of the Dutch State in gas extraction, especially in the post global financial crisis period, gas extraction rates have been at historically-high levels. A consequence of this high rate of extraction has been an increasing frequency and severity of earthquakes in the region of the Groningen gasfield. Although earthquakes have been officially accepted as a being a consequence of gas extraction in Groningen since the 1990s, the issue was not widely considered to be of significant concern until August 2012 when an earthquake (3.6 on the Richter scale), the largest in the region to date, occurred, prompting political action. Subsequently, a further shock came in January 2013 with the publication of a report by the State Supervisor of Mines which warned that larger earthquakes were possible. The media frenzy that followed fuelled community alarm, but also revealed that there had been underlying concern for a long time.

It is now widely accepted that the earthquakes have caused significant social impacts at the local level leading to a renewed discussion about the distribution of the impacts and benefits from gas production in The Netherlands. In this paper, we chronicled and analysed this issue up to January 2014. A postscript is provided to indicate subsequent changes. We note that as an ongoing issue there will be further developments that will affect some of the specificities of this case. However, as a story with relevance elsewhere, there is much of value to reflect on at this point in time in terms of understanding what social impacts are occurring, how effective the mitigation measures have been, and in thinking about what still needs to be done. Some general comments about the governance and environmental licencing arrangements can also be made.

The social impacts of the earthquakes in Groningen can be grouped into six categories: damage to property and concern about compensation mechanisms; decline in house prices; concern about the chance of dykes breaking; feelings of insecurity; health issues; and increased distrust and anger. The mitigation measures applied to date are largely inadequate and need improvement. In particular and most obviously, the damage compensation mechanism needs considerable improvement in service and speed. A procedure for mitigating physical health issues needs to be developed and the procedure for compensating reductions in house values needs to be implemented. The distrust is a fundamental problem—it is the root of most impacts, especially mental health issues and feelings of insecurity, and it amplifies other impacts, such as the effectiveness of the damage compensation service. The effectiveness of most mitigation actions is affected by the level of trust, which is currently very low. However, the lack of trust is partly related to the ineffectiveness of mitigation attempts. This downward spiral might be broken by NAM and the whole Groningen gas operation taking steps to regain its social licence to operate. NAM should engage with the community more. Also, the value of gas extraction to local people needs to be established. NAM should demonstrate they are listening to the concerns of Groningen residents by, for example, accepting some of the demands made by the inhabitants of Groningen. These demands include: reduce production; increase financial benefits to the region; establish an independent damage assessment and compensation process; ensure greater efficiency in the compensation process; and develop a fair mechanism for dealing with the decline in property values. Some of these issues have been taken up by NAM and the government, but at the time of writing, January 2014, they clearly still needed attention.

To some extent this was a story about Groningen, but there are wider lessons. There is no doubt that the exploitation of Groningen gas has had major benefits to the country as a whole—with over €10 billion (about 4.0% of all national government income) flowing into Treasury coffers annually from the State's interests in the Groningen gas operations. But there is concern that there is little benefit to local people. While there has been some employment and other benefits from gas extraction, these have tended not to directly benefit those people who live in the earthquake zone (the Groningen gasfield). The gas income has been used by the Dutch State to fund the large expenditures of various subsequent governments on social welfare, with The Netherlands historically being one of the world's leading social welfare states. There has also been major investment in physical infrastructure (also causing social impacts, see Stolp et al., 2002), with The Netherlands generally regarded as having one of the best transportation systems in the world. But there have also been further consequences of these decisions, the most famous of which is 'Dutch disease', an economics term referring to the negative consequences of exploiting natural resources on other sectors in the economy—in effect making them uncompetitive. The concept of Dutch disease, which became

popular in the 1980s, arose because of the considerable revenues from the Groningen gasfield. In the Netherlands and perhaps in social welfare circles, Dutch disease also refers to the perverse consequences of high levels of government funding on social welfare (van der Veen and Trommel, 1999). Dutch disease, in both meanings, arguably no longer occurs in The Netherlands, but remains a central component of 'resource curse' thinking (Davis and Tilton, 2005; Ross, 1999).

The Groningen gasfield has been the 'cash cow' of the Netherlands. Unfortunately, the income from gas has been used (with some saying 'squandered') to fund a range of current activities and projects, perhaps partly based on false assumptions about the longevity of the gasfield and, in an earlier time at least, the perceived boundless energy that might occur from nuclear power which was thought would be developed as the next energy source. No money was invested in any sovereign wealth fund, and apart from investment in infrastructure and to some extent education, there has been little conscious investment or thought given as to what would constitute a sustainable livelihood or economy for the people of Groningen or the nation when the gas runs out. Wise decision making in resource economies should ensure that considerable attention and investment is given to the post production (or closure) situation, and that such thinking and any underlying assumptions are reviewed periodically.

The Groningen gasfield was developed as a commercial gas production region in the 1960s, that is, before the advent of environmental impact assessment or social impact assessment (Vanclay, 2014; Vanclay and Esteves, 2011). However, the planning system in the Netherlands and the largely environmentally-responsible management of the commercial partners with oversight by the State has meant that, up until recently at least, Groningen gas production was generally seen as good practice (Ministry of Economic Affairs, 2008). However, while a degree of subsidence was always expected and planned for, the induced seismology being experienced now was not considered in the approval and regulation processes (and initial suggestions of the link between extraction and earthquakes were denied by the authorities). Thus, now there is a significantly different situation, with major social and environmental impacts officially established as occurring as a consequence of this project. With such a significant change in the predicted impacts, surely there should be a new social and environmental assessment of the project. Given the dependence of the Dutch State on revenues from the project, it is not likely that project approval would be declined. But perhaps there does need to be a new deal in relation to the flow of benefits and a new plan for managing the social impacts. In terms of the current tools in the field of social impact assessment, there should be a Social Impact Management Plan (Franks and Vanclay, 2013) developed, and an Impacts and Benefits Agreement (Gibson and O'Faircheallaigh, 2010; Nish and Bice, 2011) negotiated with the local community. A rights-compatible grievance procedure (Kemp and Vanclay, 2013) should also be developed. Only when all these things are done is it likely that Groningen gas production will regain its social licence to operate.

A decline in trust was one of the major social impacts observed, affecting not only the feelings of earthquake-affected individuals, but also influencing the corporate reputation of the commercial parties and the electoral success of the political parties. A key lesson here is that the trust issue today is very much affected by the denial of the problem decades ago—a disrespectful comment made by NAM in 1988 is currently being re-circulated. Even the regulator has been compromised by previously denying the possibility that the earthquakes were caused by gas extraction. The failure of NAM and the government to address this issue much earlier leads to people feeling hurt, and being cynical of current mitigation attempts. The reluctance of NAM and the government to acknowledge the concerns of people have not helped. While ultimately much has been done, it was only achieved because of a concerted media campaign and much lobbying by community groups, the affected municipalities and the provincial government. Unanticipated social and environmental consequences will always occur, impact assessment studies can never accurately predict all outcomes especially where it is beyond existing knowledge. All projects should be mindful of this, and more open to the possibility of unforeseen impacts occurring. By being receptive to this possibility, perhaps they can be addressed much earlier and harm reduced.

This study of the Groningen situation highlights some key issues that have bearing for environmental management generally. The lessons may be particularly relevant as resource companies explore new techniques for extracting resources, especially in relation to unconventional gas, shale gas, and fracking. For any project, there is always the potential of unforeseen environmental and social impacts, no matter how sure the geologists, geophysicists, mining engineers, and construction engineers might be of their science. This highlights a flaw in current environmental licencing systems. How is a production licence to be renegotiated when an unforeseen consequence occurs, especially when the State (which is meant to have a regulatory function) has a massive financial interest?

Postscript

On 17 January 2014, Minister Kamp, in conjunction with NAM, announced there would be a reduction in production at the Loppersum wells, the municipality that has suffered the heaviest earthquakes and most subsidence. Local production would be cut from the 2013 level of 15 billion m^3 to 3 billion m^3, while production at other sites would remain the same (Kamp, 2014). In Loppersum, this may sound impressive, but actually the total production of the Groningen gasfield will hardly be affected because production in 2013 was historically high at 54 billion m^3, well above the 45 billion m^3 average annual extraction under the cap for the period up to 2020. After the so-called cutback, overall production for 2014 will still be around 42 billion m^3. Thus, given the total production cap up to 2020, there is no real overall reduction. Kamp also outlined a €1.2 billion 5 year programme to mitigate the impacts, one third of which would be paid by NAM. Kamp promised to invest in measures to prevent damage and to invest in the economic structure of the region. He allocated €250 million for damage compensation and announced the establishment of an independent oversight committee to assess compensation for decline in property values. Despite these measures, several parties, including GBB, have announced their disappointment and feel these measures are not adequate. They feel the reduction in gas production is not a real reduction and they feel the damage compensation and damage prevention measures are not extras, but should be done anyway (RTVNoord, 2014b). Some technical people were also concerned, arguing that decisions were made for political reasons (i.e. the March 2014 elections) rather than on the basis of science. With a high probability of ongoing earthquakes, this remains an interesting case to monitor.

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