

Migration and Environmental Hazards

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Losses due to natural hazards (e.g., earthquakes, hurricanes) and technological hazards (e.g., nuclear waste facilities, chemical spills) are both on the rise. One response to hazard-related losses is migration, with this paper offering a review of research examining the association between migration and environmental hazards. Using examples from both developed and developing regional contexts, the overview demonstrates that the association between migration and environmental hazards varies by setting, hazard types, and household characteristics. In many cases, however, results demonstrate that environmental factors play a role in shaping migration decisions, particularly among those most vulnerable. Research also suggests that risk perception acts as a mediating factor. Classic migration theory is reviewed to offer a foundation for examination of these associations.

KEY WORDS: Environmental hazards; internal migration; international migration; migration; natural hazards; technological hazards; residential mobility.

Several classic theoretical perspectives on migration provide foundations for examination of the association between migration and environmental hazards. Importantly, however, while contextual factors are often *noted* in these frameworks, they are rarely emphasized. Further, to the extent that empirical work has been undertaken with regard to the association between migration and environmental hazards, little of such work is grounded in these classic migration frameworks. The purpose of this review

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is to summarize classic migration theories of potential use in the exploration of environmental context within migration research, while also providing a synthesis of existing efforts examining, more specifically, migration as associated with both natural and technological hazards.

In *Population and Development Review's* Supplement to Volume 28, a broad array of methods were presented for examination of the association between demographic and environmental change (Lutz, Prskawetz, & Sanderson, 2002). The review presented here highlights work examining, as put forth by the Supplement's Editors, the ways in which changes in the natural environment affect human population ($E \rightarrow P$). Although most of the existing research on migration and environmental hazards does not incorporate dynamic modeling of environmental processes, such efforts do offer examples of the ways in which demographers might incorporate environmental context into exploration of demographic processes.

An environmental hazard has been defined by hazard researchers as, in the broadest sense, a threat to people and their valuables (Cutter, 2001a). Interactions between social, natural, and technological systems can yield environmental hazards (Cutter, 2001a), and losses associated with natural hazards (e.g., earthquakes, hurricanes) and technological environmental hazards (e.g., nuclear waste facilities, chemical spills) are on the rise (see Pielke & Sarewize, 2004). The recent devastation wrought by tsunamis in Asia provide evidence of human vulnerability to natural forces; Pielke & Sarewize, (2004) offer a discussion of such vulnerability, particularly as related to climate, in the previous issue of *Population and Environment*.

With regard to natural hazards, it is conservatively estimated that environmental hazards caused over \$300 billion in property and crop damage and nearly 9000 deaths during 1975–1998 (Mitchell & Thomas, 2001). In developing nations, death tolls are much higher than in more developed contexts, while in developed countries, economic losses outweigh human losses (van der Wink et al., 1998). Further, it is possible that impacts will escalate, since some research portends that a warming climate may increase extreme weather events (e.g., McGuire, Mason & Kilburn 2002). With regard to technological hazards, over 6000 deaths were attributed to the 1984 gas leak in Bhopal, India, while over 135,000 residents were evacuated as a result of the 1986 accident at the nuclear power plant in Chernobyl, Ukraine. In the U.S., the continuing debate over nuclear waste storage at Yucca Mountain, Nevada, testifies as to the ongoing presence of these issues in contemporary society (Pollution Engineering, 2002; Riddle & Shaw, 2003). Today's public is, indeed, attuned to environmental hazards; as stated by risk researchers

Cvetkovich and Earle (1992:3), "complacency may have been an appropriate description of public responses to environmental hazards 25 years ago, but it is no longer apt." How this attention plays out demographically, particularly with regard to migration, is the focus of this review.

Migration as a demographic process can be associated with environmental hazards in several ways. On the one hand, proximate environmental hazards might influence residential decision-making by shaping the desirability of particular locales. In this case, we might consider environmental hazards as factors shaping migration. On the other hand, migration can represent an exacerbating force with regard to environmental hazards as a result of increasing population density in vulnerable locales. Consider, for instance, the dramatic population increases in earthquake- and hurricane-prone regions of the U.S. (Mileti, 1999) and the movement of poverty-stricken households to floodplains in Bangladesh (e.g., Lein, 2000; Zaman, 1991). In this case, we might consider migration a factor shaping the scale of environmental hazards, and the scope of the resulting disaster should one occur. Regardless of these important associations, scholarly explorations of environmental hazards and disasters as either cause and consequence of migration are few. As stated recently by the National Research Council's Committee on the Human Dimensions of Global Change (1999:57) "there is very little empirical documentation of the relationships between migration and environment."

This paper offers a synthesis of the work that has been done on the association between migration and environmental hazards, with the hope that the synthesis can provide a foundation for future endeavors in this area. The review is presented in several sections. First, classic theoretical foundations of potential use in exploration of the link between migration and environmental hazards are outlined. Second, a section on natural hazards offers brief background on the hazards themselves, followed by an overview of social science work associating migration and natural hazards. A similar section comes next, but with a focus on technological hazards. Finally, the overview is brought together in the concluding section, with two additional perspectives offered with regard to migration and environmental hazards.

It is important to note that there are environmental dimensions of relevance to migration that are not covered in this review. In particular, cumulative, slow-onset changes as related to natural processes are important particularly within the context of subsistence economies (e.g., Lonergran, 1998); deforestation, land degradation, erosion, desertification, and climate change are examples of environmental change potentially playing a role in

migration decision-making processes. These arenas are, however, left for review within another context.

THEORETICAL FOUNDATIONS: MIGRATION AND ENVIRONMENTAL HAZARDS

As mentioned, many classic migration frameworks incorporate environmental considerations (e.g., DeJong & Fawcett, 1981; Lee, 1966; Speare, 1974; Wolpert, 1966), albeit often in quite subtle ways (see Table 1). The following section offers brief reviews of classic migration frameworks by Wolpert, Speare, DeJong and Fawcett, among others, with a specific focus on the ways in which environmental hazards might be situated within these frameworks.

Perhaps the most relevant of the classic migration frameworks integrate non-economic aspects of residential satisfaction within the process of migration decision-making. Wolpert is often credited with the initial development of a migration model incorporating non-economic aspects of residential satisfaction (Fredrickson, Heaton, Fuguitt, & Zuiches, 1980). Wolpert's theoretical "stress-threshold" model (1966) critically considers the "noxious environmental influences which are far-reaching in terms of the potential strain placed upon decision-makers." (Wolpert, 1966:95) He posited that migration is a response to stress experienced from the current residential location, with residential "stressors" including environmental disamenities such as pollution, congestion and crime. The model suggests that these "stressors" bring about "strain" which may lead to consideration of residential alternatives. Further, potential migrants determine the "place utility" of alternative residential locations based upon the anticipated satisfaction derived from relocation to a particular locale.

Considerations along these lines were further developed by Speare (1974). More specifically, Speare outlined characteristics of the individual, household, housing unit location and social bonds as they influence residential mobility, arguing that individuals experience a "threshold of dissatisfaction" after which they may consider residential relocation. He operationalized "utility" into varying levels of satisfaction in order to examine the effects of social and contextual factors on individual stress thresholds. Speare argued that residential dissatisfaction may result from a change in household needs, change in a particular location's social and physical amenities, or a change in the standards used to evaluate these factors. Within Speare's framework, physical amenities (or their opposite,

TABLE 1
Classic Migration Theories and the Potential Placement of Environmental Hazards

Petersen	1958	General typology of migration
Key citation: "A general typology of migration." <i>American Sociological Review</i> , 23: 256–266.		
Potential placement of environmental hazards: As ecological "push" factor yielding migration as an "innovative" response.		
Wolpert	1966	Stress-threshold model
Key citation: "Migration as an adjustment to environmental stress." <i>Journal of Social Issues</i> , 22, 4:92–102.		
Potential placement of environmental hazards: As "stressors"		
Zelinsky	1971	Mobility transition hypothesis
Key citation: "The hypothesis of the mobility transition." <i>Geographical Review</i> , 61:219–249.		
Potential placement of environmental hazards: As related to "personal preferences."		
Speare	1974	Residential mobility decision-making model
Key citation: "Residential satisfaction as an intervening variable in residential mobility." <i>Demography</i> 11, 2:173–188.		
Potential placement of environmental hazards: As "locational characteristics"		
Various contributors		
Neo-classical migration models		
Summary: DaVanzo, J. 1981. "Microeconomic approaches to studying migration decisions." in De Jong, G.F. and R.W.Gardner (Editors), <i>Migration decision making: multidisciplinary approaches to microlevel studies in developed and developing countries</i> , pp. 90–129. New York: Pergamon Press.		
Example: Harris, J.R. and M.P. Todaro. 1970. "Migration, unemployment and development: A two-sector analysis." <i>American Economic Review</i> , 70: 126–142.		
Example: Graves, P.E. 1983. "Migration with a composite amenity: The role of rents." <i>Journal of Regional Science</i> , 23(4): 541–546.		
Potential placement of environmental hazards: As a "location-specific disamenity."		

TABLE 1 (Continued)

DeJong and Fawcett	1981 Value-Expectancy model	Key citation: "Multidisciplinary frameworks and models of migration decision making" in De Jong, G.F. and R.W.Gardner (Editors), <i>Migration decision making: multidisciplinary approaches to microlevel studies in developed and developing countries</i> , pp. 13–58. New York: Pergamon Press.
		<i>Potential placement of environmental hazards: As a personal value/goal of "comfort."</i>
Gardner	1981 Macro-micro decision-making model	Key citation: "Macrolevel Influences on the Migration Decision Process" Chapter 3 (pp. 59–89) in G.F. De Jong and R.W.Gardner (Editors), <i>Migration decision making: multidisciplinary approaches to microlevel studies in developed and developing countries</i> . New York: Pergamon Press.
		<i>Potential placement of environmental hazards: As a locational characteristic in conflict with "what people value."</i>

physical disamenities) as "locational characteristics," are of most relevance for consideration of environmental hazards.

Other relevant frameworks operating at the individual or household scale include the Value-Expectancy (V-E) model in which migration motivation is defined as a function of the *value* placed on certain goals combined with the perceived likelihood that a chosen behavior will lead to those goals; the V-E model's basic components are, therefore, goals (values, objectives) and expectancies (subjective probabilities). Several general values/goals are outlined (i.e., wealth, status, stimulation, autonomy, affiliation, morality), with the general value/goal of "comfort" likely encompassing environmental context. Included within the goal of "comfort" is a "more pleasant residential environment ... [and] ... a healthier or less stressful setting" (DeJong & Fawcett, 1981:50). Still, it is argued that decisions with regard to moving or staying are shaped by the ways in which these values/goals interact with individual and household characteristics, societal and cultural norms, personal traits, and variation in opportunity structures between areas.

Critical consideration of temporal shifts in individual- and household-level migration decisions can be found in Zelinsky's (1971) explication of the "mobility transition hypothesis." With a focus on the association between modernization and migration, Zelinsky argues that social and economic change inherent within modernization yield increases in personal freedom and declines in the difficulties inherent in breaking ties with residential origins. These changes, it is argued, enhance the role of personal preferences in migration decision-making processes (Zelinsky, 1971). Given research suggesting that individuals often express preferences for residential environments free of environmental hazards (e.g., Blackwood & Carpenter, 1978; Hsieh & Liu, 1983; McAuley & Nutty, 1982), it might be suggested that modernization increases households' ability to act freely upon these preferences for less risky residential environments.

Environmental context finds substantially less emphasis within the neo-classical microeconomic perspectives that tend to focus more on the human capital and economic dimensions of migration decision-making (DaVanzo, 1981; Harris & Todaro, 1970; Todaro, 1976). Here, migration is viewed as shaped by cost-benefit calculation with personal investment in migration behavior only being justified by sufficient returns to the behavioral investment. Environmental considerations are, in a sense, implicit here since environmental pollution or other risks may represent negative locational characteristics, while positive environmental attributes likely increase destination attractiveness. Econometric migration models have revealed associations with locational amenities (e.g., Knapp & Graves, 1989) and some

suggest that an indication of the societal value placed upon such amenities, or disamenities, is reflected in wage differentials across locations (Knapp & Graves, 1989). Certainly in the conventional economic model, population movement acts as an equilibrating mechanism reducing geographic wage differentials (DaVanzo, 1981), yet these wage differentials are, themselves, often due to variation in location-specific amenities (e.g., Graves, 1983; Knapp & Graves, 1989; Mathur, Stein, & Kumar, 1988; Mueser & Graves, 1995; von Reichert & Rudzitis, 1994). The existence of location-specific amenities (or disamenities) is important, because migration is the only way to consume (or avoid) them. To be more specific, within the neoclassical framework individuals might accept somewhat lower pay to reside in a location with environmental amenities; conversely, individuals might have to receive higher compensation to continue to live in an environmentally unattractive or hazardous locale.

Linking macro and micro characteristics, Petersen's early typology of migration (1958, 1975) describes innovative or conservative migration behavior with specific incorporation of ecological "pushes" as a type of migratory force. He argues, however, that ecological forces tended to shape migration in primitive times and that a conservative response would yield nomadic tendencies within the risky area in an effort to recreate *status quo* without long-distance relocation. Innovative response would, instead, entail a flight from the risky area more generally to find a less risky ecological context.

As a final conceptual consideration, Gardner's (1981) work on the migration decision-making process aimed to identify particular stages within the decision-making process at which the effect of macro-level factors should explicitly be considered. He identified five such points: (1) formation of values; (2) real, place-related macro-level factors; (3) factors that affect accurate perception of place-related factors and thus one's expectations; (4) objective constraints and facilitators to migration, and; (5) factors that affect accurate perception of the constraints and facilitators (1981:63–64). Of particular interest within Gardner's efforts is consideration of the individual's formation of values, since it is these values that will shape perception of the local environment. As he states, studies of migration behavior rarely deal with the formation of values, although such work has been undertaken with regard to other demographic processes, namely fertility (Gardner 1981:65). In a sense, Gardner's efforts link macro- and micro-through arguing that *what people value* shapes perceived fulfillment at present location, with feelings of stress and dissatisfaction as related to macro context and value orientation creating preferred residential locations. These efforts reflect a more explicit consideration of the place of values

within residential satisfaction, and therefore represent an extension to work by Speare (1974) and DeJong and Fawcett (1981). Gardner (1981:88) concludes:

The study of migration decisions, while necessarily proceeding on the micro-level, must nevertheless take into account at all steps the influence of macrofactors, the social and institutional, the economic and *the geographic context* within which the individual exists [emphasis added].

As per Gardner (1981), Speare (1974) and others, residential preferences represent the proverbial glue holding together the connection between migration and environmental context. Social science research has revealed significant effects of perceived neighborhood quality on metropolitan net migration (Schacter & Althaus, 1982) and that climate (summer humidity and winter severity) is a significant determinant of migration patterns (Schacter and Althaus 1982; Walters 1994) within the context of the U.S. In addition, levels of air pollution and healthy environments are often noted as desirable residential attributes (e.g., Blackwood & Carpenter, 1978; McAuley & Nutty, 1982). Further, Hsieh and Liu (1983) argue that in the short-run, "pursuance of better *environmental quality* is the dominant factor in explaining interregional migration" (emphasis in original, p. 431). The rural turnaround of the 1970 s in the U.S. suggested that environmental amenities such as mountains, lakes and "other areas of natural beauty" represent contextual characteristics of importance within rural destinations as well (e.g., DeJong & Sell, 1977:177).

That said, as Slovic (1987) argues, people respond to the hazards they perceive; as such, while amenities may act as migratory "pulls", is the converse necessarily then true that disamenities act as migratory "push"? Specifically, relocation in response to nearby environmental hazards cannot simply be assumed since individuals may not be aware of, or concerned with, the danger posed. Risk assessment reflects human judgments, with these judgments influenced by various psychological and social factors (Cvetkovich & Earle, 1992). Several reasons can be outlined as to why residents might not migrate from hazard-prone areas. Residents may:

1. not be aware of hazard;
2. be aware, but do not expect a disaster;
3. expect a disaster, but do not anticipate loss;
4. expect loss, but not serious loss;

5. expect serious loss and have undertaken, or are planning to undertake, loss reduction actions;
6. expect loss, but have accepted as costs of gaining locational benefits;
7. have no choice in location (Kates,1962; expanded by Fordham,1992).

If aware of hazards, four mechanisms of adjustment are possible: (1) engineering mechanisms (technological adjustments); (2) symbolic mechanisms including culture (norms and values), (3) regulatory mechanisms (policy), and (4) distributional mechanisms (movement of people, activities, resources) (Micklin,1973; Mileti,1980). The focus within this review is on population distribution through migration. A useful heuristic is presented by Hugo (1996) in his work on environmental concerns as related specifically to international migration. Hugo (1996:107) presents a continuum whereby population mobility is viewed as ranging from totally voluntary, in which migration is entirely resultant of the choice and will of the migrants, to forced, where migrants face death in their present location. Migrants forced out of places of origin due to environmental disruption have been termed, in some contexts, as "environmental refugees" (e.g., Jacobsen, 1988), although this terminology has proven problematic, since such refugees do not fit within conventional political definitions.

In the end, many classic migration frameworks offer potential for the specific inclusion of environmental hazards as contextual characteristics. Nonetheless, there has been a limited amount of scholarly work undertaken with regard to the migration-hazard association, with virtually none integrating these classic migration conceptualizations. The following section focuses specifically on natural hazards, reviewing some examples of contemporary work that has been undertaken with regard to migration and natural hazards.

MIGRATION AS A RESPONSE TO NATURAL HAZARDS

First, a definition: natural hazards are defined as those "extreme events that originate in the biosphere, lithosphere, hydrosphere or atmosphere" (Alexander, 2000:9) "that pose a threat to people, their property and their possessions" (McGuire, Mason and Kilburn, 2002). Many natural hazards are recurrent in time and relatively predictable in terms of location, although this is not always the case.

The impacts of natural hazards on society are substantial and are clearly on the rise (Abramovitz 2001). While severe storms, floods, and earthquakes result in lower levels of mortality than socio-political

phenomenon such as civil strife, these natural hazards are more frequent occurrences and more generally affect relatively greater numbers of individuals (Smith, 2001). Indeed, estimates suggest that between 1/5 and 1/4 of the Earth's human population was affected by natural hazards during the 1970s and 1980s (Abramovitz, 2001). Even so, impacts are expected to increase; during the period 1972–1995, actual calamities increased by 5–7% per year, while the damage resultant of these disasters increased by 5–10% per year (Kondratyev, Krapivin, & Phillips, 2002). Predictions to 2030 suggest a continuation of these trends in addition to their “enhancement” (Kondratyev et al., 2002). Anticipated future increases in human impacts of these extreme events are due to two factors: population growth and resultant increases in the built environment in regions most vulnerable to high impact natural disasters, namely coastal and urban areas (Mileti, 1999).

Also important with regard to the social context of natural hazards is social variation in vulnerability (Blaikie, Cannon, Davis, & Wisner, 1994; Girard & Peacock, 1997), with “vulnerability” defined as the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a hazard. Most vulnerable are those at the low end of the socio-economic spectrum, both in developed and developing regions. Research has shown that SES is associated with hurricane mitigation in southern Florida, with low-income households more likely to live in highly vulnerable mobile homes and less likely to have invested in disaster mitigation such as hurricane-resistant windows and roofing (Peacock & Girard, 1997). They are also more likely to have insufficient insurance and, therefore, inadequate settlements for rebuilding (Peacock & Girard, 1997). In developing regions, the poorest inhabitants are often forced to live on marginal land outside urban areas or coastal zones potentially prone to flood risk (e.g., Chan, 1995). In an aggregate sense, a direct relationship exists between the level of development and type of natural disaster losses. In developing nations, death tolls are much higher than in more developed contexts, while in developed countries, economic losses outweigh human losses (van der Wink et al., 1998).

Migration on a Continuum:

As noted above, a wide-ranging continuum characterizes the ways in which environmental hazards might act as a “push” factor in migration decision-making. With regard to natural hazards, forced migration is represented by evacuation (e.g., Ziegler & Johnson, 1984), although this movement is typically only temporary and does not entail a permanent

change of residential location. Some disaster-impacted residents do eventually choose to relocate, however, thereby engaging in voluntary migration. The wholesale relocation of communities represents another potential migratory outcome of natural hazards, also representing more permanent residential location. Such relocation is often mandated (therefore forced) migration, and will therefore be reviewed first below. As presented, the reviewed literature moves from forced migration to increasingly voluntary migration as a response to natural hazards.

Community relocation is one of three forms of reconstruction typically undertaken by disaster-impacted communities (Mileti & Passerini, 1996). Reconstruction most often follows the path of rebuilding, whereby communities are reconstructed to restore their predisaster character with such efforts driven by human interest to reconstruct predisaster culture and interactions. Second, a community may be partially reorganized to take variation of risk within its boundaries into account. Changes in predisaster land use may, for example, restrict residential redevelopment in flood zones, instead zoning these areas for more flexible uses (e.g., recreational space). Finally, communities may be relocated to a less hazardous site, thereby requiring migration (of varying distance) but reducing future damage (Mileti & Passerini, 1996). The story of Valmeyer, Illinois, offers an example. A village of 900 residents located 35 miles southwest of St. Louis (Rozdilsky, 1996), Valmeyer flooded regularly, but following devastation by the 1993 Mississippi River floods, the community took rapid action to initiate a complete village relocation project. Flood water had reached depths of 10–15 feet in the village center, destroyed the town's infrastructure, and severely damaged 98% of the village's structures. In October, 1993, a new town site was established outside of the flood plain, on top of a nearby bluff, and in April 1995, the first resident moved into his home in the new town. The community, which includes many of the town's residents prior to the flood, has reconstructed itself with a new sense of permanence (Rozdilsky, 1996).

Wholesale community relocation is, however, a relatively rare occurrence, especially within the context of developing nations. Environmentally induced permanent migration of a less organized kind typifies these interactions in less developed contexts. Hugo (1996) presents an analysis of reports on Asian environmental migrants as presented in the *United Nations Disaster Research Organization News* for the period 1976–1994. The results demonstrate that over the last 2 decades environmental disasters have displaced increasing numbers of people. As an example, in 1994, mass migration to urban areas within China took place as a result of floods and droughts in upland areas (Kaye, 1994). Natural calamities also often “push”

migrants from rural to urban areas in Bangladesh, such that "an unusual increase of beggars and people looking for work in cities and towns is part of the aftermath of drought and floods." (Population: UNFPA Newsletter, 1984). It has been argued that millions are displaced annually as a result of environmental factors in Africa as well.

Local displacement also takes place, such as in portions of Bangladesh, where floods and cyclones regularly occur, often with dramatic outcomes (Lein, 2000; Zaman, 1991). Importantly, local displacement in contexts such as Bangladesh is sometimes temporary and may, therefore, not represent "migration" under technical terms requiring longer-term relocation. Still, these situations are noted here as instances where environmental context may consistently yield residential disruption especially within less developed contexts.

Agriculture in Bangladesh is very much dependent on annual flooding and the floods, therefore, take on unique cultural meaning. Although necessary, the persistent floods also change river courses, with many Bangladeshis losing homes and lands to erosion annually (Zaman, 1991). In a survey undertaken in a Bangladesh floodplain in the mid 1980s, 64% of sample households reported having been displaced by erosion at least once, with the mean number of displacements being seven (Zaman, 1991). Typically, migrant households relocate only a short distance away; in the aforementioned survey, nearly 88% of households had remained within 2 miles of their previous residence (Zaman, 1991). Such short distance mobility (perhaps temporary) is a product of lack of resources, presence of kin, and belief that land will re-emerge to be reclaimed (Zaman, 1991). Migration here is a household coping mechanism, with household members typically having little faith in finding permanent residence; displacees often continue to live in fear of eviction, either by governmental authorities or natural forces (Haque & Zaman, 1989; Mutton & Haque, 2004; Zaman, 1991).

Sometimes, however, migration (short- or long-term) as a coping strategy is simply not feasible. Demonstrating the interaction between vulnerability and exposure to environmental hazards, in Peninsular Malaysia, structural factors restrict the residential choices of many inhabitants of risk-prone regions (Chan, 1995). Based on 1992–1993 interviews with members of 618 flood-prone households, Chan (1995) argues that migration is an option available only to wealthier households, while options are restricted for many others due to poverty, low educational attainment and social mobility, insecure land tenure, a lack of government aid, disaster preparedness and/or relief programs (Chan, 1995). Further, if provided the opportunity to relocate, many vulnerable households do so only to often

find themselves on *different* floodplains because these are the least expensive places to live.

As another form of migratory response to environmental hazards, in some cases, particular household members will take on more permanent migration while others stay behind. Here we can look to work by Ezra and Kiros (2001) in ecologically degraded and drought-prone communities in Ethiopia. Multilevel models estimating young adult migration within this context provide evidence for the "new economics of migration," whereby migration of some household members becomes a family strategy for those living in uncertain natural environments. Results suggest that a community's vulnerability to food shortages as a result of drought contributes significantly to outmigration as a strategy to assist relatives (Ezra and Kiros, 2001).

Household migration strategies as related to natural hazards are also seen in South America. On May, 31, 1970, a major earthquake struck Peru, killing as many as 70,000 residents and injuring 150,000 others. Osterling (1979) studied the ways in which this catastrophe contributed to outmigration of peasant workers from the highland region of Ancash, the area most destroyed by the quake, to Huayopampa a rural community 4\h drive north of Lima. Results suggest that most migrants were compelled to seek employment through migration because the natural disaster had intensified traditional poverty in their origin villages. Only a handful of migrants indicated that the earthquake was their primary migration motivation. Indeed, the natural disaster is seen to have stimulated an ongoing process of modernization and acculturation, primarily with regard to Ancash young men, by "forcing some of the victims to seek their fortunes within a labor economy" (Osterling, 1979: 120). Migrants were innovative in responding to the earthquake by capitalizing on social networks that facilitated migration to Huayopampa which is seen as a training ground for preparation for an eventual permanent move to Lima (Osterling, 1979).

Within the context of the U.S., making use of the American Housing Survey, Morrow-Jones and Morrow-Jones (1991) find that, as compared to migrants generally, those noting natural disaster as the reason for their move tend to be older, are more likely female-headed households and minority group members, and are characterized by lower income and educational levels. As such, the researchers conclude that the less socio-economically advantaged may be those most likely to migrate following a natural disaster. It is suggested that those households with more assets may be more likely to rebuild (Morrow-Jones & Morrow-Jones, 1991), perhaps as a result of lessened damage due to their ability to undertake more mitigation measures such as installation of disaster-resistant windows and/or roofs (Peacock & Girard, 1997).

In the end, research clearly suggests that natural hazard risks are “dynamic and complex” (Alexander, 2000:11), as are the relocation responses of households to natural hazards. Within developing regions, descriptive work suggests that millions migrate annually as a result of environmental conditions, suggesting that environmental decline may be an important “push” factor fueling urbanization (e.g., Hugo, 1996; Jacobsen, 1988). In some cases, local (perhaps temporary) mobility is a more typical response to regularly occurring natural hazards (e.g., Zaman, 1991). Finally, analytical efforts suggest that the environment as a contextual factor, interacts with individual, household and other community characteristics to shape household migration decision-making (e.g., Ezra & Kiros, 2001). Within more developed regions, there is some evidence that “flight” from hazardous areas is as much related family composition, community ties, and job status as concern with the risk itself (Goldhaber, Houts, & DiSabella, 1983). Other evidence suggests that, in more developed regions, socio-economically advantaged households may be those least likely to migrate in response to natural hazard impacts (e.g., Morrow-Jones & Morrow-Jones, 1991).

The following section provides a review similar to that above but with regard to technological hazards. First, hazards are defined. Following, several case studies illustrate research findings linking migration to technological hazards.

MIGRATION IN RESPONSE TO TECHNOLOGICAL HAZARDS

Human societies, technology, and the natural environment interact to yield technological hazards (Thomas & Mitchell, 2001). Such hazards are often the product of complex systems, with some scholars arguing that failure within these systems is inevitable (Perrow, 1984, 1999). As distinguished from natural hazards, technological hazards might yield releases of toxic materials, episodes of severe contamination, structural collapses, and transportation, construction or manufacturing accidents (Alexander, 2000: 9). The 20th century has several dramatic examples to offer with regard to technological disasters including a fatal gas leak in Bhopal, India (1986), radioactive releases from nuclear plants in Chernobyl, Ukraine (1986) and Three Mile Island (TMI), Pennsylvania (1979) and toxic contamination of a residential neighborhood in Love Canal, New York (1978). A geographic bias exists within social research relating population redistribution to these hazards in that the majority of scientific explorations have been undertaken within developed nations.

In general, the public expresses high levels of “dread” and fear with regard to many technological hazards (e.g., Slovic, 1987). Indeed, risk assessment experts are often perplexed by the public’s concern with hazards that are technically assessed as relatively minor risks (Cvetkovich & Earle, 1992; Erickson, 1994; Kunreuther, Flynn & Slovic, 2001; Treichel, 2000). Some argue that the invisible nature of many environmental toxins, in addition to the uncertainty of potential health effects, play important roles in the magnification of perceived risk and the difficulties in determining the severity of hazard (Thomas & Mitchell, 2001). As stated by Erickson (1994), these “new species” of trouble:

are seen as having been produced by human hands, they involve some form of toxic contaminant, and they blur the line we have been in the habit of drawing between the acute and the chronic (Erickson 1994:22).

More explicitly, the “social amplification” of technological risks is the product of, not only direct physical consequences, but interaction of psychological, cultural, social, and institutional processes that amplify or attenuate public experience of risk. In particular, risk perception is shaped by media coverage, level of dread, and cultural placement of blame (Kasperson, Renn & Slovic, 1988; Renn, Bruns, Kasperson, Kasperson, & Slovic, 1992).

Migration on a Continuum:

First reviewed are two cases in the U.S. that represent one end of the migration continuum—forced migration—as a result of technological environmental hazards. First, in a widely publicized case, in 1980 President Carter ordered a total evacuation of Love Canal, New York and signed an appropriation bill providing funding for permanent relocation of 900 families (CHEJ undated). The relocation was a result of human exposure to toxic chemicals as suggested by chemical odors, skin problems and spontaneous chemical fires. In 1942, Hooker Electrochemical Company had purchased a canal as part of a failed residential development and the area was consequently used as a burial site for 19,000 metric tons of hazardous waste. After being covered with earth and clay, the site was sold to the school board of Niagara Falls in 1953 for one dollar and, the following year, a school and residential community were built on the site (Paigen, Goldman, Magnant, Highland, & Steegmann, 1987; Vyner, 1988).

As another example of hazard-induced involuntary migration, in 1982, the EPA condemned the small town of Times Beach, Missouri after discovering dangerous levels of dioxin, a potent carcinogen. Years earlier, in an effort to control dust, waste oil had been regularly sprayed on the town's streets from an industrial vat where the Vietnam-era defoliant Agent Orange was once stored; dioxin is a byproduct of the production of germicides and herbicides. Concern first surfaced in the late 1970s when horses began dying at a riding stable whose arena had been sprayed, but not until 1982, was it confirmed that residents of the town at-large had been exposed. Following EPA and CDC studies, in early 1982, in a joint federal-state action, the EPA, the Federal Emergency Management Agency (FEMA), and the State of Missouri allocated resources for the permanent relocation of Times Beach residents (EPA, 1983). The EPA released \$33 million to FEMA to purchase 801 permanent and mobile homes, and relocate over 2000 residents and more than 40 businesses.

Still, such relocation efforts are certainly the extreme with regard to migratory response to technological environmental hazards. More often, temporary evacuation is a short-term relocation response, but many residents eventually return home. Even in the wake of evacuation in response to a fatal gas leak in the Bhopal, India, epidemiological research revealed a lack of large-scale permanent outmigration (Dhara & Dhara, 2002). The environmental hazard posed by the TMI incident also provided a research context in which to explore the dynamics of voluntary migration.

At 4:00 AM on March 28, 1979, a reactor at the TMI nuclear power facility near Harrisburg, Pennsylvania suddenly overheated, releasing radioactive gases. Over the next several days, radioactivity was sporadically released from the plant and approximately 60% of the population living within 5 miles was evacuated (Goldhaber et al., 1983). The median distance traveled was 85–100 miles (Zeigler & Johnson, 1984). In an exploration of TMI-related outmigration, Goldhaber et al. (1983) found that only 1–2% of the population within a 5-mile radius appeared affected by the crisis in such a way that they permanently moved from the area, and that other factors such as job and family characteristics had considerably greater effect on moving than did attitudes about TMI.

Of course, tracking post-disaster migrants such as undertaken by Goldhaber et al. (1983) is difficult since their migration destinations are mostly unknown. An alternative perspective might query residents of affected communities with regard to their *desire to move*. As suggested by Gill and Picou (1998:804), "contamination and subsequent uncertainty regarding exposure, long-term environmental damage, and the alteration of lifescape reduce the quality of life in contaminated communities." As might

be expected, slightly more residents expressed a desire to move as a result of TMI, as compared to those households who actually did migrate. Flynn (1979) found that 17% of household heads living within 5 miles of TMI responded that someone in their household had "considered moving, while only 6% reported that someone has "definitely" decided to move because of TMI (as presented in Goldhaber et al. (1983)).

A somewhat different finding emerges from work following a series of explosions in Haifa, Israel, in December 1988 (Kirschenbaum, 1996). Approximately 3000 residents were evacuated after the explosions that emanated from a "gas farm" containing about 1100 tons of liquid cooking gas. Hazardous materials at nearby petrochemical plants also ignited. Interviews with 100 evacuated household heads within 2 weeks of their return home revealed nearly half emphatically desired to relocate. The desire to move was particularly discernible for better educated respondents and those with greater potential loss of fixed assets. Also, of prime concern was the perceived psychological damage that parents felt their children experienced as a result of the disaster event, compounded by a sense of helplessness during the event itself (Kirschenbaum 1996).

Gill and Picou (1998) also examined migration intentions in comparative work exploring social response to three technological hazards or disasters: a train derailment in Livingston, Louisiana, a Superfund site in the Southbend subdivision of Houston, Texas, and the Exxon Valdez oil spill in Prince William Sound, Alaska. Gill and Picou (1998) found that, following these disasters, residents viewed their communities as less desirable places to live, and between 29 and 79% of residents desired to move, while 14–83% expected to move from the affected areas. In particular, residents of the Superfund community expressed especially high levels of outmigration desires, with perceived threats to the physical health of self and family associated with greater desire to relocate.¹

Of course, in-migration may also be effected by environmental hazards, whereby migrants see potential destinations as less attractive as a result of disamenities. Making use of choice experiments, Greenwood, McClelland, and Schulze (1997) examined the effects of perceptions of hazardous waste on the destination choices of potential migrants. The authors conclude that the presence of a nuclear waste repository makes a difference in destination selection; potential migrants are dissuaded from selecting a location with a repository, even if the repository poses little risk. Greenwood et al. (1997) also conclude that employment conditions are a particularly important consideration in the migration decision-making process, particularly of young migrants.

Results from aggregate analyses complement these individual-level explorations. Through modeling of aggregate population movements as associated environmental hazards, Hunter (1998) finds that U.S. counties with environmental hazards such as air and water pollution, hazardous waste and Superfund sites do not lose residents at greater rates than areas without such hazards. Areas with such risks do, however, gain relatively fewer new residents. These findings are corroborated by Murdock et al. (1999), who examine six counties impacted by hazardous facility development relative to their "non-waste" counterparts. Results suggest that waste-impacted counties did not have substantially different patterns of population change than non-waste counties. As related to long-term changes in waste counties, the researchers argue that waste development appeared to partially abate rates of population decline rather than lead to reversals in patterns of growth (Murdock et al. 1999). The results of both Hunter (1998) and Murdock et al. (1999) support earlier work by Flynn (1979), Goldhaber et al (1983), and Gill and Picou (1998) suggesting relatively little outmigration as a product of technological hazards (although their might be *desire*). Still, such hazards may be likely to deter prospective migrants, as suggested by Greenwood et al. (1997).

SUMMARY, CONCLUSIONS, IMPLICATIONS

The review provided above has examined migration as a particular coping strategy with regard to environmental hazards. In general, although research on migration and the environment "remains weak" (Bilborrow, 2002:87), the work that has been done documents that migration is a coping strategy undertaken by some households in the face of both natural and technological hazards (e.g., Morrow-Jones & Morrow-Jones, 1991). That said, there is also evidence that "flight" from hazardous areas is sometimes as much related to family composition, community ties, and job status as concern with the risk itself (Goldhaber et al. 1983). The following summary links insights from the review to classic migration theory in addition to theoretical conceptions of risk perception, while also discussing the policy implications of the summary's conclusions.

As might be anticipated due to migration's various costs, more households typically express *desire* to relocate as a result of proximate hazards than actually do (Flynn 1979; Goldhaber et al. 1983). Such findings support Speare's (1974) conceptual efforts with regard to residential preferences in which he argues that consideration of migration is a necessary, but not sufficient, condition leading to actual migration behavior. In

addition, Speare notes that factors related to residential context interact with individual and household characteristics to shape migratory behavior (Speare, 1974). Indeed, although research suggests individuals prefer hazard-free living situations (e.g., Blackwood & Carpenter, 1978; McAuley & Nutty, 1982), individual, household, or other contextual factors may simply not allow migration behavior in response to those preferences.

Linking risk perception to migration, in the wake of a disaster event, a geographic place may be recast with the disaster-afflicted negative image of the area affecting relocation decisions (Kielcolt & Nigg, 1982; Kirschenbaum, 1996). Research suggests that this "risk image" can be a powerful factor in the willingness of individuals to return to the area and/or stay in their homes (e.g., Dynes & Quarantelli, 1976). This "risk image" is illustrated by work in Times Beach, Missouri following recognition of contamination but prior to the community buy-out. Residents who had not yet moved reported greater levels of anxiety, alienation and stigma reflecting their "distaste for living in such close proximity to dioxin" (Goodman, Vaughan, & Gill, 1992). Of course, tradeoffs exist whereby there are perceived costs of continuing to reside in a risk area, or an area perceived as posing risk, that are judged against the perceived benefits gained—despite the risks (Kirschenbaum, 1996).

Typically, poor, disenfranchised individuals, and minority groups, must make these tradeoffs, as these social groups are more exposed to the dangers of both natural and technological hazards relative to others (Cvetkovich & Earle, 1992:2). Importantly however, this vulnerability manifests itself differently according to context and type of hazard. Here, the framework put forth by Kates (1962) and expanded by Fordham (1992) becomes useful. Recall the several reasons outlined as to why residents might not migrate from hazard-prone areas. Residents may:

1. not be aware of the hazard;
2. be aware, but do not expect a disaster;
3. expect a disaster, but do not anticipate loss;
4. expect loss, but not serious loss;
5. expect serious loss and have undertaken, or are planning to undertake, loss reduction actions;
6. expect loss, but have accepted as costs of gaining locational benefits;
7. have no choice in location (Kates, 1962; expanded by Fordham, 1992).

The above review provides evidence of several such rationales. With regard to natural hazards, in less developed regions, hazardous areas are often settled by poor households, perhaps because they *have no choice in residential location* (e.g., Chan, 1995). In more developed regions, more

advantaged households tend to remain in hazardous areas, and rebuild in the face of disaster (e.g., Morrow-Jones & Morrow-Jones, 1991), perhaps because they have *expected loss, but accepted these losses as costs of gaining locational benefits*. In addition, some research suggests that socio-economically advantaged households are more likely to have undertaken mitigation strategies (e.g., Peacock & Girard 1997), thereby suggesting they may have *expected serious loss and have undertaken, or planning to undertake, loss reduction actions*.

With regard to technological hazards, research suggests that structural factors may inhibit migration, in other words, some households *have no choice in location*. Recall the circumstances surrounding Love Canal where regardless of the *desire* to relocate, community residents were confronted with many different obstacles. As expressed by activist Lois Gibbs:

Hazardous wastes can turn a home that most people have worked so hard to buy into a toxic prison, which they can't afford to sell (even if they could find a buyer) and can't afford to stay in because of what the chemicals are doing to their health (as presented in Freudenberg, 1984:9).

The lack of large-scale migration from the area surrounding Bhopal, India in the wake of the fatal gas leak in 1984 (Dhara & Dhara, 2002) may also be associated with structural forces impeding migratory options.

In addition, some research suggests that concern with environmental context may not be sufficient motivation for relocation. As Wolpert notes (1966), an individual may accept a negative, yet stable, environment rather than face the stress associated with change. Short-distance relocation may be an option here, in a survey of Bangladeshi floodplain residents, nearly 88% of migrant households had remained within 2 miles of their previous residence (Zaman, 1991). Such migration harkens to Petersen's classic migration typology (1958) in which he argues that a "conservative" migration responses remain within the risky area in an effort to recreate the *status quo* without long-distance relocation. Innovative response would, instead, entail a flight from the risky area more generally to find a less risky ecological context. Such efforts are, perhaps, reflected by the "economic migration" of select household members from some hazard-prone contexts (e.g., Ezra & Kiros, 2001; Osterling, 1979).

There are two other interesting perspectives from which to explore the association between migration and environmental hazards. First, as an alternative to the notion of "flight" from environmentally risky areas, we

might think of the tradeoffs that households consider in their quest for a satisfactory residential environment. The earliest economic frameworks posited that migrants tend to choose destinations that offer the highest level of benefits. As defined by Graves (1983: 542, these benefits are, "at the most general level, the variations in utility that result from occupying alternative locations." As an example, Nelson (1978) quantifies the value of air quality as the impact of air pollution on residential property values, and suggests that households more sensitive to the tangible and intangible effects of air pollution will take up residence in areas with relatively clean air. These types of arguments suggest that socioeconomically disadvantaged households may accept proximate environmental risk in order to achieve affordable housing, perhaps related to #4 (*expect loss, but not serious loss*) in the Kates/Fordham (1962/1992) framework.

Second, and also as related to risk perception, some evidence implies that outsider perceptions of environmentally hazardous residential contexts may be fundamentally different from residents, thereby suggesting the importance of not imposing risk judgement when undertaking analyses on these associations. Two examples offer illustration. First, in a study of "environmentally devastated neighborhoods," Greenberg and Schneider (1996) visited several communities characterized by technological hazards. Upon visiting a community with a nuclear power plant, Greenberg engaged in discussion with three residents. First, he spoke with an Asian American male approximately 35 years old, who had recently relocated to the neighborhood. The "insider" explained that he perceived the nuclear station, located about two miles from his house, as a windfall because it paid such a large proportion of municipal taxes. His property taxes were low, the school had excellent teachers, and his children were getting free violin lessons (Greenberg & Schneider, 1996:7). Second, Greenberg spoke with a Caucasian woman, approximately 70 years old, who lived about four miles from the nuclear power station. She felt that the utility company that managed the station was "doing the best they could," and that the electricity had to be produced somewhere. Although she had recently decided to move, her decision was based on the fact that her house was too large to maintain (Greenberg & Schneider 1996:7-8). Third, the owner of the local fruit stand suggested that Greenberg stop "gawking at the station" and go visit the nearby river if he "really wanted to see what the place is like (p. 9)." The researchers concluded that the "insiders saw, felt, heard, smelled, and responded to the entire place they lived in, not just the part that outsiders focused on" (Greenberg & Schneider, 1996).

In similar findings from research across the globe, Lein (2000) examines environment, hazards, and migration among residents of a *char*,

new land formed through accretion, located in the middle of Jamuna river in Bangladesh. He concludes that "it is misleading to perceive the *chars* as high-risk areas filled with marginalized, poor people living on the brink of disaster." (Lein, 2000:126) Instead, although life on the *char* is somewhat burdensome, residents contend that it is also rewarding and perhaps not as dangerous or disaster-prone as an outsider might think. Lein (2000) presents work by Schmuck-Widmann (1996, 76) who concluded:

The perceptions of *char*-dwellers of their living conditions is fundamentally different from the view taken by outsiders. Life stories and accounts clearly suggest that flood and erosion do not have the character of catastrophe to them, contrary to the reports of press agencies and development institutions. They are recurring events, forming part of the *char* dwellers' life-world. The people have adjusted and are not helpless victims of their environment.

The studies by Greenberg and Schneider (1996) and Lein (2000) both suggest the importance of considering insiders' risk perception in examination of migration as related to environmental hazards. They provide support for Slovic's (1987) contention that people respond to the hazards they perceive. Indeed, it is perhaps the *perception* of risk even more so than the probability of hazard occurrence that may be more related to migration. In a sense, these findings can be incorporated within the Value-Expectancy migration framework, whereby migration is a function of the *value* placed on certain goals, combined with the perceived likelihood that migration will lead to those goals. One such goal is "comfort" defined as a "more pleasant residential environment ... [and] ... a healthier or less stressful setting" (DeJong & Fawcett, 1981:50). Per Greenberg and Schneider (1996) and Lein (2000), neither *char* residents, nor residents of the neighborhood proximate to the nuclear power plant, appear to perceive their residential environment as necessarily unpleasant, or not to the degree that migration is a requisite response.

Another especially interesting category of hazards has been termed "na-tech" (for natural-technological, McGuire et al. 2002). Such a category can be used to describe complex disasters for which there is a recognizable and substantial human contribution. Consider the devastating flood in Buffalo Creek, West Virginia where, on February 26, 1972, a makeshift mining company dam burst resulting in 132-million gallons of debris-filled water raging through a narrow mountain hollow. The hollow's tight knit

communities were destroyed, with devastating social consequences (Erickson, 1976). More recently, in 1998, large-scale logging was a major contributory factor in the devastating flooding of the Yangtze basin in China (McGuire et al. 2000). To control Yangtze flooding, the Three Gorges Dam has generated a “na-tech” disaster which will ultimately inundate 13 cities, 140 towns and more than 1000 villages, resulting in the resettling of more than 1 million residents (Chao, 2001; UNEP, 2003).

Examining the reciprocal nature of this association, migration represents not only a response to environmental hazards, but can also an exacerbating force with regard to risk. Also as related to “na-tec” hazards, the impact of many apparently “natural” disasters are largely the product of human decision-making, particularly as related to land use and socioeconomic activities (Alexander, 2000). Large-scale human migration to cities and coastal areas is putting more people and infrastructure at risk (Abramovitz, 2001; McGuire et al. 2000), and as such, the scope of potential damage from “natural hazards” has increased. In developing regions, environmental factors in origin locations often play a role in rural-urban migration, thereby fueling urbanization and the settling of oft-impooverished migrants in hazard-prone locales (e.g., Chan, 1995; Kaye, 1994; Lein, 2000).

In developed regions, high amenity regions, such as coastlines, act as migrant “pull” factors. In the U.S., although coastal counties (excluding Alaska) constitute only 11% of land area, they are home to 53% of the population (Culliton et al., 1990; Culliton 1998). California, Florida, Texas and New York consistently account for a significant portion of coastal population growth. Indeed, from 1980–1990, central Atlantic coastal barrier counties had growth rates of up to 300%, while Florida coastal counties experienced net growth of up to 781% (Bartlett, Mageean, & O’Connor, 1999). Rapid migration to coastal areas also characterizes population patterns in southern Europe (Hinrichsen, 1998), thereby increasing hazard vulnerability and disaster potential. Coastlines aren’t the only desirable hazardous environments; Palm (1981) investigated whether knowledge of earthquake hazards in amenity-rich, but earthquake prone areas, deterred people from making home purchases and found that it did not. Such development patterns clearly illustrate that societal impacts from environmental hazards are the result of natural phenomena in combination with socio-economic trends such as coastal population growth (Mileti, 1999; Pielke & Sarewitz, 2004).

In the end, although hazards are an inescapable part of life (Cutter, 2001b; Smith, 2001), vulnerability varies, as does the ability of individuals and households to engage in a range of coping strategies. The recent disastrous tsunamis in southeast Asia illustrate all-too-clearly human

vulnerability to environmental extremes. Indeed, as the year 2004 came to a close, some dubbed it the “year of disasters,” with a wide variety of options characterizing potential societal reactions to these environmental extremes. Such options include cultural adjustment related to shifting norms and values, regulatory mechanisms typically in the form of policy, or distributional mechanisms involving the movement of people, activities, resources (Micklin, 1973; Mileti, 1980); the focus of this review has been on population distribution through migration.

Research suggests that the form of migration resultant of environmental hazards ranges across a continuum from forced to voluntary, and that the association between migration and environmental hazards varies by context, hazard type, and household characteristics. That said, there is substantial opportunity for demographers to contribute to a better societal understanding of population distribution as related to environmental hazards; Numerous secondary data sources reflecting environmental hazards are readily available, and classic migration theory has much to offer.² Exploration of the link between population distribution is particularly timely since scholars predict increases in both natural and technological hazards, as well as increased human vulnerability due to population growth and shifts in population distribution and related infrastructure. Policymakers may find insights into migration decision-making of particular use in the creation of policies designed to reduce human vulnerability. Indeed, human coping strategies take many forms and the strategies chosen by hazard-impacted individuals will ultimately shape the success of policies aimed at reducing the social and economic losses associated with environmental hazards.

NOTES

1. There are over 1300 Superfund sites across the U.S., and as such, these represent fairly widely distributed technological hazards. Given this broad distribution and the fact that these sites often receive little public attention, the association with migration might be anticipated to be different as compared with large-scale, singular, widely publicized technological hazards such as Yucca Mountain. Nonetheless, research exploring the association between migration and Superfund sites remains covered in this review.
2. There are several secondary data sources of potential use in examination of environmental hazards as contextual factors in migration research including the National Oceanic and Atmospheric Administration (NOAA), the Environmental Protection Agency (EPA) and the FEMA. Also, Belgium’s Centre for Research on the Epidemiology of Disasters (CRED) offers a database (EM-DAT) that documents both natural and technological disasters around the world, while additional information has compiled from various sources such as UN agencies, NGOs, insurance companies, and research institutes.

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