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Natural hazards affect human well-being in several ways. They destroy livelihoods, cause huge losses in production, reduce income and damage property. Many poor people in developing countries are especially vulnerable to natural risks, not only because they depend on agricultural production as their major source of income, but also because they are often obliged to settle in risk-prone areas such as hillsides, river basins, etc. It has become even more important to find adequate means to manage natural risks because climate change is causing many of them to increase in frequency and degree.

Micro-insurance for natural risks has been proposed as a helpful tool to improve poor peoples' risk management, and several development-cooperation projects have been initiated in order to promote micro-insurance for natural risks. However, it is not yet clear which risks are insurable in micro-insurance and which are not. This paper therefore analyses which natural risks could be covered by micro-insurance and shows how this can be done.

In order to determine the natural risks that could be covered by micro-insurance, a conceptual framework has been developed that adapts current work on the insurability of risks to the case of micro-insurance. This framework is then applied to four different natural risks that can serve as examples for most other natural risks. For example, drought risk can be insured similarly to extreme fluctuations in temperature. The insurability of hail risk, in turn, is representative for storm and typhoon risks, while flood risk poses the same difficulties to micro-insurance as the risk of tsunamis, landslides and volcanic eruptions. Finally, the results from analysing the insurability of livestock diseases are equally applicable to other pests and diseases.

Six criteria determine if a risk is insurable in micro-insurance or not. Different micro-insurance schemes are best suited to cover the risk – depending on the degree to which the following criteria are fulfilled: *First,* the loss must be accidental and unintentional. If it cannot be clearly observed, whether or not the loss was unintentional, only community-based schemes can cover the risk because these schemes are better suited to prevent moral hazard. *Second,* the chance of loss must be calculable – by using a wide range of information about the probability of occurrence and the expected loss. *Third,* in order to prevent adverse selection, the insurer needs to be able to classify policyholders according to their individual risk profiles. Because community-based schemes have better access to information about the insured, they might have comparative advantages in assessing the risk profile of the insured. *Fourth,* the losses should be determinable and measurable at relatively low cost. If this is not possible, an index must be used to approximate losses. In most cases, only full-service insurers have the technical capacity to offer index insurance. *Fifth,* in order to adequately diversify the risk a sufficiently large risk pool must be formed. For highly covariant risks, for example, only large insurance companies with access to international reinsurance are able to guarantee sufficient risk pooling. And *sixth,* micro-insurance should be the most adequate risk-management strategy, which means that no other risk-management strategy (such as risk prevention, mitigation or coping) should be superior to it in terms of cost-efficiency and effectiveness.

Applying this framework to natural risks shows that only losses in agricultural production can be covered by micro-insurance, while property damages cannot be covered. Differentiating by the cause of risk, the following results are derived:

– Drought risk can be insured in micro-insurance by a full-service insurer. The production losses need to be approximated by an index because on-the-ground loss assessment would be too expensive and allows for moral hazard. Due to the high covariance of this risk, only large insurance companies with access to international reinsurance can cover it.

– Hail risk is also insurable in micro-insurance but can only be covered by an innovative micro-insurance scheme. Since the loss assessment requires on-the-ground visits, group insurance must be introduced in order to hold down transaction costs. This risk is not currently covered by micro-insurance because large insurance companies prefer providing index-based micro-insurance, as these are easier to manage and because community-based schemes cannot cover this risk.

– The risk of river flood is theoretically insurable, but requires very precise topographic data in order to prevent adverse selection: Advanced technologies have to be used in order to assess the losses in agricultural production through remote sensing. Because the precise data and technology required are not yet available in many developing countries, it is still difficult to insure river flood risk in micro-insurance.

– Livestock diseases, finally, are not easily insurable, since most of them can be prevented by sound management practices. Only a very few diseases are insurable, and these risks have to be covered by community-based schemes in order to guarantee immediate loss assessment.

Despite the fact that different natural risks can be covered by micro-insurance, there is room to improve the outreach and efficiency of micro-insurance for natural risks by creating an innovative micro-insurance scheme. A promising way to organise a more comprehensive scheme is a national micro-insurance scheme that incorporates community-based insurance schemes in a national umbrella organisation. In such a national micro-insurance scheme, idiosyncratic risks could be covered by the community-based schemes, while the national umbrella would be responsible for covering covariant risks.

Such a comprehensive micro-insurance scheme would be able to cover a wider range of natural risks by combining the advantages of existing schemes. Idiosyncratic risks such as certain pests and diseases could be covered, as well as covariant risks such as hail, storms, river floods, tsunamis and landslides. Droughts and fluctuations in temperature could still be covered by index-based micro-insurance. That way, the scheme would not only be able to cover in one contract those risks that have already been insured in micro-insurance, but could also extend the range of insurable risks to cover such risks as hail and storms that are theoretically insurable in micro-insurance, but for which no coverage yet exists.

1 Introduction

Natural hazards can destroy livelihoods, cause huge losses in production and damage the property of the affected population. This is especially true for poor people in developing countries, as agricultural production is the main source of income for large sections of the population. Because small-scale and subsistence farmers are highly dependent on advantageous weather conditions, climate change makes them even more vulnerable. Other natural risks also play important roles in the lives and livelihoods of poor people in developing countries. Poor people, for example, are often forced to settle in areas more prone to be hit by natural disasters, such as river-banks or hillsides, where they are very exposed to the risk of losing property and income.

Especially in developing countries, the State often cannot afford, or is not willing to provide, protection against natural disasters. In the aftermath of catastrophic events, people have to hope for assistance from the international community, although this emergency relief is not reliable and depends on several factors such as media attention, the extent of the damage and other factors beyond the control of those affected. How else can poor people cope with the natural risks that threaten their livelihoods? While wealthy citizens are able to protect themselves through insurance and reserve accumulation, low-income groups have to rely almost exclusively on informal risk-management strategies. Such strategies are usually community-based and fail when the whole community is affected, making poor people especially vulnerable to most natural hazards.

Changing weather trends due to climate change have brought about more frequent and more extreme weather events leading to huge losses in agricultural production and to increased property damage (Höppe 2007, 369). These shocks deeply affect people, and call for innovative and comprehensive risk-management strategies. Micro-insurance has been proposed as a promising tool for managing natural risks in developing countries. It has been suggested that micro-insurance could cover the increased volatility of losses associated with climate change. The need to enhance disaster risk-reduction strategies, including insurance and micro-insurance, is addressed in the Cancún Adaptation Framework established by the UNFCCC (United Nations Framework Convention on Climate Change) in December 2010 (UNFCCC 2011, 5).

In recent years, several development-cooperation projects have been initiated to promote micro-insurance for natural risks in low-income communities. While some projects were successful, supporting the notion that micro-insurance is indeed an effective tool for managing natural risks, other projects failed or lost significance as soon as external funding was reduced. Often the choice of risks to be covered followed no systematic pattern, and it seems possible that many programs failed because of special conditions in micro-insurance that altered the general framework for insurability.

The aim of this paper is therefore to analyse which natural risks can be covered by micro-insurance and to show how this can be done. The paper concludes that many natural risks can be covered by micro-insurance, but that the optimal insurance scheme for providing coverage is different according to the type of risk. An innovative micro-insurance scheme is proposed to improve the outreach and efficiency of micro-insurance for natural risks.

The paper is organised as follows: In Chapter 2, the basic concepts relating to risks, risk management and micro-insurance are introduced. Chapter 3 discusses the criteria that risks

have to meet in order to be insurable and adapts them to the specific conditions of micro-insurance. In Chapter 4, this conceptual framework is applied to four different natural risks, namely drought, livestock diseases, hail and river flood. These risks have been chosen because they are representative of many other natural risks and because the literature on these risks is relatively well-developed. Representative case studies provide further evidence on how these results are reflected in empirical evidence. Chapter 5 concludes and proposes an innovative micro-insurance scheme for natural risks.

2 The basic concepts: risks, risk management and micro-insurance

Uncertainty about the future influences individual behaviour in many aspects. Because people are risk averse, the prospect of suffering income losses due to hazards reduces their well-being. People therefore try to avoid risks and seek to protect themselves against negative consequences from unavoidable hazards such as illness, accidents or unemployment.

2.1 Risk, hazard and vulnerability

A hazard is defined as the event that causes loss. For example, a hazard could be an accident that destroys property and therefore causes additional expenditures. While the occurrence of hazards is random, they are nevertheless expected to occur with a certain probability (Rösner 2008, 18).

From an economic perspective, a risk is defined as the variance in income or expenditures that is associated with the realisation of a hazardous event. This means that a risk can be understood as the expectation of losing income or assets from a hazard.

The variance in income or expenditures associated with a hazard describes the expected amount of actual loss, for example, the value of destroyed property or the cost of medical treatment. The expected size of the loss is not only determined by the severity of the hazard, but also by the vulnerability of the individual or object to this hazard.

Box 1: Some definitions
Hazard: A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. **Risk:** The combination of the probability of an event and its negative consequences. **Vulnerability:** The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. **Risk management:** The systematic approach and practice of managing uncertainty to minimize potential harm and loss. **Risk pooling:** The process of formally or informally shifting the financial consequences of particular risks from one party to another whereby a household, community, enterprise or state authority will obtain resources from the other party after a disaster occurs, in exchange for ongoing or compensatory social or financial benefits provided to that other party.
Source: UNISDR (2009)

Vulnerability designates the susceptibility to damage. In the case of a car accident, the vulnerability of the car would depend on the quality of its construction. In social protection literature, in contrast, vulnerability is often used to describe the likelihood that a certain hazard will reduce an individual's well-being (World Bank 2001, 139). In this sense, poor people are more vulnerable to income disruptions than rich people, because they are less likely to have accumulated savings that would allow them to cope with the shock.

When analysing the insurability of risks, it is useful to make a clear distinction between the different characteristics of risks. Risks can be classified according to the underlying hazards, their levels of occurrence and their effects.

Risks have mostly been classified according to their underlying hazards, for example, the natural hazard that causes property damage or the economic crisis that causes unemployment. A natural risk is the risk of losses in production or property due to potentially damaging natural events. Box 2 provides an overview of different natural risks and their levels of occurrence.

The level of occurrence determines if a risk is idiosyncratic or covariant. Idiosyncratic risks affect one person at the time, while covariant risks affect many people simultaneously and within the same area. Highly covariant risks for example, are those risks that occur at the macro-level.

The effect of the risk describes the nature of the damage that is to be expected, for example, whether the health of the insured, or their income or property will be affected. Most natural risks can damage property, cause losses in agricultural production, affect health and lead to loss of life.[1]

Box 2: Natural risk by nature and level of occurrence

	Micro-level	Meso-level	Macro-level
	Idiosyncratic ◄——————►		Covariant
Hydro-meteorological risks		Hail Storm Flood	Temperature Drought
Biological risks	Livestock disease	Pests Epidemics (livestock)	
Geological risks		Earthquake Tsunami Landslide Volcanic eruption	

Source: The author's design, based on Holzmann / Jørgensen (2000, 4)

1 This paper only considers losses in agricultural production and property damage caused by natural hazards. While natural hazards can also affect human lives and health, life micro-insurance and health micro-insurance, respectively, would cover these risks. Because of the small role that natural risks play in the functioning and sustainability of life and health micro-insurance products, these will not be considered in this paper.

2.2 Risk-management strategies

Because risks affect human well-being, people have always sought ways of managing them. Different risk-management strategies have been developed in order to deal with a wide range of risks. Three groups of risk-management strategies can be distinguished according to their objectives: risk-reduction, risk-mitigation and risk-coping strategies (World Bank 2001, 141).

Risk-reduction strategies target the source of risk and aim to reduce the probability of risk occurrence. Such strategies include the construction of dams in flood-prone areas, and also the avoidance of that risk by choosing not to settle in coastal areas.

Risk-mitigation strategies, in contrast, aim at limiting the impact of the shock. This can be done by diversifying income sources, by accumulating buffer stocks or by pooling the risk with a larger group through insurance.

Risk-coping strategies, finally, designate measures that are taken to relieve the impact of shocks that have already occurred. Such strategies include drawing down savings or reducing food intake.

All these risk-management strategies have advantages and disadvantages. Because this paper focuses on micro-insurance, it seems helpful to briefly describe the basic principles of insurance and micro-insurance.

Insurance is a risk-pooling instrument with which risks are transferred from the insured to the insurer in compensation for regular premium payments. Insurance contracts assure that the insurer will indemnify the insured for the damage caused by the occurrence of the insured risk.

Micro-insurance, then, is a risk-pooling instrument especially designed to address the specific needs of the poor (Churchill 2006, 12). However, the target group of micro-insurance providers is not restricted to those parts of the population living below internationally defined poverty lines. According to Nabeth (2006, 37), micro-insurance is designed to reach all segments of the population that are excluded from access to conventional insurance products due to financial, social, cultural or logistical constraints. The necessity to provide specific products for those groups, results not only from their low purchasing power but also from discrepancies between the groups' needs and the standardised insurance products and distribution networks that are mainly designed for the needs of the urban upper- and middle-income population.

2.3 Micro-insurance schemes

In practice, micro-insurance rarely reaches the poorest segments of the population, as they often lack the financial means to pay even for low premium rates (Loewe 2006, 53). In order to improve access to micro-insurance, it has been widely discussed how best to distribute micro-insurance products and which micro-insurance schemes would be best suited to increase the outreach of micro-insurance (see e.g. Loewe 2009; McCord 2008; Brown / Churchill 2000). The three following schemes have been proposed:

In the first scheme, the full-service insurance scheme, one single institution is responsible for product design, marketing and servicing. This institution could be a commercial insurance company, a MFI (micro-finance institution) or a third-sector welfare organisation (Loewe 2006, 40–43). In this paper, mainly commercial insurance companies will be considered under this scheme, as MFI and welfare organisations lack the necessary know-how and risk-pooling instruments to offer micro-insurance. While know-how can be bought in, one important feature for providing micro-insurance is the ability to form a sufficiently large risk pool. An insurance company can form large risk pools and also has access to reinsurance and capital markets. A major drawback of insurance companies is their difficulty in obtaining information about the risks profiles and behaviour of micro-insurance clients (Loewe 2006, 41).

In the second scheme, the community-based or mutual insurance scheme, risks are shared between the members of a group or network. The risk sharing can be either ex-ante, by making regular contributions to a common fund, or ex-post, by providing support in case one member experiences a loss. Such schemes are mainly community-based, which is why they will be designated as community-based insurance schemes below. The advantage of community-based schemes is that they often have good access to information about the needs of the target group. Furthermore, in these schemes, risk profiles and behaviour are more easily observable. The main drawbacks to such schemes are that they lack the necessary know-how to effectively design and manage insurance products, and they cannot cover covariant risks, since these cause several simultaneous claims and would jeopardise the financial sustainability of the scheme (Coheur et al. 2007, 3–4).

The third scheme, the partner-agent scheme, combines advantages of the two schemes described above. The agent can be any local organisation or community-based insurance scheme that has access to information about the clients' needs and behaviour. The partner, a market-based insurance scheme or a public insurance scheme, is responsible for product design and overall risk management. Important synergies can be created through the cooperation of partner and agent. The agent can improve its members' access to sound insurance products and manage the underwriting process, while the partner benefits from access to information about the needs of the clients and the distribution of products through the agent.

In some cases, synergies can be further strengthened. For some risks, the agent can handle the loss assessment and adjustment and then transfer the supporting documentation to the partner. The partner then reimburses the agent after controlling for the correctness of the claims (McCord 2006, 364). This further reduces transaction costs because the partner does not need to assess each case individually and increases timeliness in loss adjustment.

This additional reduction of costs, however, is only possible for losses that can be assessed transparently, for example, if claims can be verified through objective documentation. In such cases, the partner-agent scheme offers advantages beyond the exchange of information and the reduction of underwriting costs. Life-cycle risks, for example, are best covered in partner-agent schemes because objective documentation, such as death or medical certificates, is usually available and can be transferred to the partner.

For other risks, especially for many natural risks, individual loss assessment is indispensable. In such cases, loss assessment and adjustment works exactly as in the full-service in-

surer scheme. Therefore, the conceptual framework discussed below principally refers to the full-service-insurer and the community-based schemes. This does not imply that partner-agent approaches are not suitable in these cases, but simply that they will face the same difficulties as full-service insurers.

In the following analysis, the micro-insurance schemes will be taken as references when discussing the conditions that risks must fulfil in order to be insurable. It will be shown that each scheme provides different advantages in overcoming difficulties that emerge from the violation of some insurability conditions. These conditions will be developed below.

3 A conceptual framework: determinants of the insurability of risks in micro-insurance

The aim of this chapter is to develop a conceptual framework that establishes conditions for the insurability of risks and then discusses their validity in the special case of micro-insurance. Using this, a set of conditions is proposed that risks have to meet in order to be insurable in micro-insurance. The general conditions are mainly derived from the two pioneers in insurability analysis, Berliner (1982) and Rejda (2008); their application to micro-insurance is based on evidence gathered from practitioners and researchers working on the subject.

In order to be insurable in micro-insurance, a risk needs to fulfil the following conditions: First, the loss must be accidental and unintentional. If it cannot be clearly determined whether or not the loss was unintentional, deductibles can be introduced in order to prevent moral hazard. Second, the chance of loss has to be calculable. For this, availability of a wide range of information about the risk is crucial. Third, the insurer needs to be able to classify policyholders according to their individual risk profiles. Fourth, the losses should be determinable and measurable at relatively low cost. Building a risk pool large enough to adequately diversify the risk is the fifth condition, and sixth, micro-insurance should be the most adequate risk-management strategy, which means that no other risk-management strategy (whether risk prevention, mitigation or coping) should be superior in terms of cost efficiency and effectiveness.

3.1 Accidental und unintentional loss

The most basic condition that a risk has to meet in order to be insurable is randomness. This implies that it must be impossible to state ex-ante whether or not the risk will occur. It also entails that the chance of loss has to be beyond the control of the insured (Rejda 2008, 21). Risk pooling only makes sense, because policyholders do not know ex-ante whether or not a potential loss will occur. Otherwise, potential policyholders would only purchase insurance if they knew they would be affected.

It is often difficult for the insurer to assess whether a loss has occurred accidentally and unintentionally. As the insurer often cannot observe the behaviour of the policyholders, he cannot know if they ignored safety standards or behaved carelessly. This information asymmetry impedes insurance provision in many cases, because the insured have incen-

tives to behave differently after they have purchased insurance. This is the case for car drivers who are less careful in traffic because they know they will be indemnified for minor damages. This phenomenon has been described as moral hazard. Moral hazard violates the condition that a loss has to occur accidentally and unintentionally, because the policyholder can intentionally ignore safety measures or reduce efforts in loss mitigation. This changes the probability of loss, requiring an adjustment of premium rates. In turn, adjustment of premium rates will disadvantage those policyholders who do not change their behaviour and will eventually reduce their demand for insurance. For this group, no appropriate insurance can be offered, and in extreme cases, the insurance market for those risks will disappear.

In practice, however, a lot of risks that do not fulfil this condition are insured. Examples include all forms of liability insurance, as well as property insurance for cars, houses, etc. The risks covered are insurable, as long as the insurance contract is designed so that the policyholder has no incentives for moral hazard (Nguyen 2007, 96). A common method to prevent hidden actions is the introduction of deductibles or co-payments.

In the case of micro-insurance, though, mainly risks that are beyond the control of the insured are to be covered. This is because it is more complicated to introduce deductibles in micro-insurance, since the insured value is already low. If a deductible further reduces the sum disbursed in case of loss, potential buyers might see no advantage in purchasing the policy (Vaté / Dror 2002, 136). In most cases, community-based insurance schemes can prevent moral hazard, as information asymmetries are less likely to exist at the community level. This was discussed in Chapter 2. It has to be recognised, however, that community-based schemes can only cover idiosyncratic risks. The reason for this will be discussed in Chapter 3.5. As long as the scheme cannot guarantee the prevention of moral hazard, the community-based scheme is not likely to cooperate with a partner in order to cover more covariant risks.

3.2 Calculable chance of loss

In order for a risk to be insurable, it must be impossible to know ex-ante whether or not it will occur. However, the chance of the risk materialising, as well as the damage associated with it, must be calculable (Arrow 1984, 11). If this is not possible, no actuarially fair premium can be calculated and the insurer risks insolvency should the claims systematically exceed their calculated value.

The fair premium is usually calculated as the product of the expected indemnities and the probability of loss.[2] In order to be able to calculate this, the insurer needs a wide range of information. Statistical data can provide information about the probability of loss, the size of the average damage and the variance of losses. But since these variables can change over time (Rejda 2008, 22), this information is not always sufficient. This is the case for climate risks, for example. Changes in the amount of the average loss, on the other hand, occur due to a change in construction materials that are more or less vulnerable to natural hazards such as earthquakes or floods. It is therefore essential to obtain more data from experts or through computer simulations. The calculation of the premium is especially

2 The premium rate, then, is usually constituted of the fair premium plus administrative charges.

difficult for rare and catastrophic events. Calculating the exact probability can be difficult only because the reporting of such events does not go back far enough in time. Defining whether a risk is insurable under this criterion includes checking whether sufficient information about the risk can be obtained in order to calculate the premium, and if this information is not readily available, evaluating how costly it will be to obtain.

The condition that the premium must be calculable is equally important for micro-insurance. But insurability is further restricted by the fact that this information should be available at relatively low cost. Because the target group's ability to pay for insurance is limited, reducing administrative costs is one of the preconditions for providing micro-insurance. Therefore, in micro-insurance, those risks are insurable for which information about the probability of occurrence and the associated average loss is available at low cost. Otherwise this cost would have to be added to the premium, further reducing the demand. If information on probability and average loss is not readily available, one option to cover the risk might be to set the premium at an estimated value in the beginning and adjust it if it does not seem to be fair. This option should be considered with caution, however, because it increases the risk of insolvency.

3.3 Sufficient information to conduct risk classification

In addition to the necessity of calculating exact premium rates, the insurer should be able to classify policyholders according to their individual risk profiles. This is a prerequisite for preventing adverse selection.

Individual risk profiles can vary greatly throughout the population. For example, car drivers can be more or less cautious, or certain construction materials might be more susceptible to damage than others. If information on the individual risk profile is available to the insured but not the insurer, the variance in risk profiles can cause adverse selection. Adverse selection occurs when asymmetrical information allows the insured to know his individual risk profile, while the insurer knows only the average for the general population. Because the premium calculated for the average population will seem too expensive for low-risk individuals, only high-risk individuals will purchase insurance. This will, in turn, jeopardise the insurer's solvency, since the amount of claims will systematically exceed the calculated mean (Rothschild / Stiglitz 1976, 634). No adequate solution can be offered to low-risk individuals; in extreme cases, the market will collapse entirely. This is why it is important that the insurer is able to classify the policyholders according to their individual risk profiles – as long as this information is also available to the insured (Gollier 2001, 460). If there are no information asymmetries between insurer and insured, either because both know the exact risk profile of the insured or because neither does, the risk is insurable.

For micro-insurance, the condition that the insurer must be able to classify policyholders according to their risk profiles is particularly important. It determines the risks that must be covered by community-based insurance schemes, and the risks that also could be managed by full-service insurers. Since community-based insurance schemes have good access to information about their members, they are supposed to be better able to classify policyholders according to their risk profiles (Loewe 2009, 153). Therefore, if the individual risk profile cannot be observed easily, risks should be diversified within the community. But if it doesn't cost much to observe the individual risk profile, the risk can also be covered by an insurance company.

3.4 Determinable and measurable loss

In order to prevent fraud the insurer must be able to observe whether or not a risk has occurred, and to assess the exact loss associated with it (Rejda 2008, 21; Gollier 2001, 462). Otherwise the policyholder might have incentives to make false claims. The process of loss assessment should also be transparent to all stakeholders; this reinforces the policyholders' trust in their insurer.

The need for losses to be determinable and measurable has caused insurers lots of trouble. Loss assessment can be very costly, translating into higher premium rates. However, the decision not to assess each and every loss increases incentives for fraud. One way to solve this problem would be to design an index-based insurance. Under such a contract, the indemnity payment is no longer disbursed on the basis of individual loss assessments, but rather depends on the realisation of a chosen index (Hess et al. 2005, 15). This index should use variables that are exogenous to the individual policyholders, yet also highly correlated with the loss against which the insured seeks protection.[3] Examples include observable weather events, such as rainfall of temperature, that impact on agricultural production.

The need to determine and measure losses at relatively low costs is particularly important for micro-insurance. This means that losses have to be easily verifiable through objective documentation, for example, through death certificates or medical prescriptions. If objective documentation is not available, risks can be covered by community-based schemes, through index-based insurance or group contracts. In community-based schemes, information asymmetries and related fraud are less of an issue. Additionally, proximity to the members allows for cost-efficient loss assessment. Full-service insurers, in contrast, cannot afford to send an agent to remote areas every time a loss has occurred: the associated transaction costs would far exceed the fair premium and make the policy prohibitively expensive. Therefore, they need to rely on objective documentation of the losses. But because this is often impossible, effort has been invested in designing appropriate index-based micro-insurance. However, the difficulty of finding an index that approximates the real damage should not be underestimated. Another option would be to insure those risks that cause simultaneous losses for a lot of policyholders in the same region. In such circumstances, the transaction costs could be divided among all the claimants. This is only possible if many policies are sold in the same community or region, for example, through a group contract (Clarke 2010, 10), and if all policyholders are affected by the same hazard. Although group insurance is not yet common in developing countries, it is a promising tool to increase the outreach of micro-insurance.

3.5 The feasibility of risk pooling

In order to sustainably manage risks, the insurer has to be able to pool risks over a sufficiently large and diversified portfolio. The minimal size of the risk pool is determined, inter alia, by the covariance of risks.

3 Unfortunately, index-based insurance has the disadvantage of creating basis risk. If the correlation between the index and the actual loss is not exact, no effective risk-management will be achieved and the insured may lose confidence in the insurance company.

While insurers cannot accurately estimate the loss experienced by each and every insured individual in a given year, they can nevertheless estimate the expected losses in their aggregate portfolio. According to the law of large numbers, the higher the number of policies in a portfolio, the more accurately the expected value of the insurer's indemnity payments will approximate their actual value. This means that the variance in annual payments decreases with the size of the portfolio. This statistical property, however, only holds as long as the risks in the portfolio are not positively correlated. The covariance of risks is often due to geographical proximity that either allows for contamination, or simply because one hazard simultaneously affects many policyholders. If the no-covariance assumption is violated, the payment of one indemnity will always be associated with the payment of further indemnities. The variability of payments will not further decrease with the size of the portfolio, but instead will increase. This is why covariant risks have to be pooled over a much larger and geographically more diversified risk pool than idiosyncratic risks. If the losses on the overall portfolio are highly variable due to covariant risks, and if the portfolio is not diversified enough to pool the risks adequately, the insurer will either need to hold large reserve funds or to purchase reinsurance, both of which will increase the cost of providing insurance (Shaik et al. 2006, 59).

Being able to build a sufficiently large risk pool is especially critical for insuring risks in micro-insurance. The degree of covariance between risks determines which risks can be covered by which micro-insurance scheme. If risks are idiosyncratic, it should be possible to build a risk pool on community level that is large enough to adequately manage that risk. Therefore community-based schemes are suited to cover idiosyncratic risks. If, however, it is expected that most or all the members of a community will be affected by the same hazard, the risk pool must be larger. Such covariant risks have to be insured through insurance companies or the government and, depending on the degree of covariance, it might be necessary for them to purchase reinsurance. Drought risk, for example, is highly covariant and is usually reinsured by international reinsurance companies. If the cost of reinsurance is high, it could reduce demand and restrict the insurability of covariant risks in micro-insurance.

3.6 The adequateness of insurance as a risk-management strategy

The insurability of risks is not only determined by actuarial and market-determined conditions, but also by the adequateness of insurance as a risk-management strategy. In this sense, risks are insurable if, in terms of cost efficiency and effectiveness, no other risk-management strategy is superior to insurance.

Risks reduce the well-being of people. Therefore, people seek to protect themselves against risks and assess which risk-management strategies are best. This is why demand for insurance partly depends on the availability and cost of alternative risk-management strategies (Zweifel / Eisen 2003, 49). Available risk-management strategies range from measures of risk reduction and prevention to income-diversification strategies. This condition implies that some risks will have to be classified as not insurable although insurance provision is technically feasible. For example, risks with very low probability are hard to insure because the demand for insurance that covers these risks is expected to be too low. This is also true for very high-probability risks: In such cases, the fair premium is so high that it almost equals the expected loss, adding transaction costs to the fair premium would

then make it by far too expensive. These conditions are similar with regard to the value of the expected loss: If the value is very low, insurance will not be the most cost-efficient risk-management strategy because the administrative and transaction costs are very high relative to the fair premium. In such cases, coping is the more efficient risk-management strategy. Insurance may also fail if the expected loss is so high that the fair premium far exceeds the insured's ability to pay. This is true for health risks, which can get so high, that many individuals cannot bear them. This is why some authors (e.g. Loewe 2009, 188) claim that only those risks for which the average loss depends on the income level are insurable. For health risks, insurance is at best a second-best solution. Since many people cannot afford to manage their health risks, the State should cover them. But since many national governments are unwilling to do that, people find it necessary to purchase insurance to cover at least part of their health risks.

Micro-insurance is generally the most adequate risk-management strategy for covariant risks. In most cases, the clientele for micro-insurance is used to getting along without insurance and already manages risks through a wide range of strategies. Even if insurance is objectively the better risk-management strategy, the target group may prefer other, mainly informal risk-management strategies. In such cases, insurance providers should focus on potential complementarities between informal and formal risk-sharing arrangements, for example, by focusing on large-scale and covariant risks. It might be interesting for insurance providers to analyse the market in detail, since existing informal networks could facilitate the distribution of insurance products.

The conceptual framework outlined in this chapter provides the necessary tools to assess whether or not a particular risk can be insured in micro-insurance. In the next chapter, this framework will be applied to different natural risks to determine which risks can be covered by micro-insurance.

4 Assessing the insurability of natural risks in micro-insurance

This chapter assesses the insurability of natural risks in micro-insurance. Four natural risks – drought, river flood, livestock disease and hail – are analysed. Case studies examine if the theoretical results are reflected in empirical observations. These case studies are representative of the experiences of many insurers regarding livestock disease and drought insurance. No example could be found for hail insurance, since the risk is currently only covered by State-owned and heavily-subsidised insurers. The flood-risk case study is about the only river-flood micro-insurance ever established. Unfortunately, it is no longer offered.

The above-mentioned risks were chosen because they are representative for other natural risks. For example, the risk of drought can be insured similarly to fluctuations in temperature. The insurability of hail risk also applies to storm and typhoon risks, while flood risk poses the same difficulties to micro-insurance as the risk of tsunamis, landslides and volcanic eruptions. Finally, the results of the analysis of the insurability of livestock diseases are equally applicable to other pests and diseases. The risk of earthquakes is the only natu-

ral risk that is not covered by the analysis.[4] Similarities in the insurability of risks are partly due to the same degree of the covariance of risks. But more importantly, some of these risks share other properties, such as duration, loss trajectories, etc., that make them similarly insurable.

The analysis reveals that most risks can be covered by micro-insurance. However, it becomes clear that only agricultural-production losses and not property damage can be covered by micro-insurance. Differentiating by the hazard that causes the damage, the following results can be derived:

Box 3: Insurability conditions in micro-insurance applied to natural risks

	Drought	**Hail**	**River flood**	**Livestock diseases**
Accidental and unintentional loss	Fulfilled for index insurance	Generally fulfilled	Generally fulfilled	Fulfilled for non-preventable diseases
Calculable chance of loss	Generally fulfilled	Generally fulfilled	Requires very precise data	Difficult
Risk classification	Generally fulfilled	Only for crop losses	Requires very precise data	Generally fulfilled
Determinable and measurable loss	Fulfilled for index insurance	Costly, except for group insurance	Only for crop losses	Costly
Sufficient risk pooling	Generally fulfilled	Generally fulfilled	Generally fulfilled	Fulfilled for idiosyncratic diseases
Adequate risk-management strategy	Fulfilled if probability is sufficiently low	Only for crop losses	Only for crop losses	Fulfilled for non-preventable diseases
Risk insurable in micro-insurance	Yes, by a full-service insurer	Yes, only by an innovative micro-insurance scheme	Difficult, by a full-service insurer scheme	For very few diseases, by a community-based scheme

Source: Author

Drought risk can be insured in micro-insurance as long as the production losses are approximated by an index and reinsured internationally. Due to the high covariance of this risk, only large national or international insurance companies can cover it.

Hail risk is also insurable in micro-insurance. But because the loss assessment requires on-the-ground visits, group insurance must be introduced to keep transaction costs low. Currently this risk is not covered by micro-insurance because large insurance companies prefer providing index-based micro-insurance, which is easier to manage, and community-based schemes cannot cover this risk.

The risk of river flood is theoretically insurable, but requires very precise topographic data in order to prevent adverse selection. Additionally, advanced technologies have to be used to assess the losses in agricultural production through remote sensing. As precise data and

4 As earthquakes are mainly associated with property damage and life risks, they need not be considered here. We will see further on why property damage cannot be covered by micro-insurance; it has already been mentioned why this paper does not consider life insurance.

the required technologies are not yet available or are not yet used in many developing countries, insuring the risk of river floods in micro-insurance is still difficult.

Livestock diseases are not easily insurable, as most of them can be prevented by sound management practices. Only a very few diseases are insurable and these risks have to be covered by community-based schemes in order to guarantee immediate loss assessment.

4.1 Drought

Drought can cause severe losses in agricultural production. Subsistence farmers in many developing countries are especially dependent on regular rainfall. Drought can lead to crop loss and livestock deaths, and even cause human hunger and death. Further, drought is a highly covariant risk that affects large areas – sometimes even a whole country – at the same time. This attribute applies equally to fluctuations in temperature. Both risks also tend to occur over longer spans of time.

Increasing awareness of climate change has brought increased attention to drought-risk insurance in recent years. Index-based insurance has been promoted as an innovative means of insuring the risk and in recent years, such schemes have spread widely. Earlier, the risk of drought could only be covered by traditional agricultural insurance that made indemnity payments based on individually assessed losses and was subject to difficulties, including high transaction costs, moral hazard, fraud and adverse selection. Traditional crop and livestock insurance had to rely on heavy subsidisation and was roundly criticised.

The risk of crop- and livestock-production losses as a result of drought is insurable in micro-insurance as long as index-based insurance is applied. Index-based insurance, however, can only provide effective risk management when basis risk is kept at a minimum. Furthermore, since the premium rises with the probability of drought, the demand for insurance shrinks with increased drought risk. Due to the high covariance of this risk, only large companies with access to international reinsurance are able to cover it. Purchasing reinsurance further increases premium rates and reduces the benefits from insuring against that risk. The arguments for covering drought risk are enumerated in more detail below.

The first condition for insuring risks in micro-insurance is that *losses have to be accidental and unintentional*. But moral hazard jeopardises the insurability of drought risks. While the insured clearly cannot control rainfall, the losses associated with it are not always obviously attributable to its lack: Mismanagement of either livestock or crops can cause similar losses (Roberts 2005a, 18). Therefore the first criterion, accidental and unintentional loss, is not fulfilled if indemnity payments depend on the individual producer's realised yield because it is not possible for the insurer to precisely identify the cause of the damage. However, index-based insurance could solve this problem of moral hazard, since the indemnity payment would be directly linked to the amount of rainfall and the farmer would have no incentives for mismanagement.

The second criterion, the *calculable chance of loss*, is usually fulfilled but depends on the farmer's production pattern. For most traditional crops, it is possible to calculate the expected damage caused by drought. For livestock insurance it should even be possible to compare meteorological data with data from a livestock census in order to calculate the expected loss (Roberts 2005a, 18). Nevertheless, it is necessary to have a sufficiently long

series of meteorological data to be able to accurately estimate the exact probability of loss. Unfortunately, in many low-income countries reliable data are more difficult to come by than one would expect (Hellmuth et al. 2009, 24; Skees / Collier 2008, 11). Furthermore, droughts often lead to sky-rocketing prices for commodities in the affected areas, so that indemnity payments alone cannot guarantee the supply of basic goods to the affected population. In such cases, emergency relief must be provided by the government or by international organisations.

With regard to *risk classification*, the risks associated with drought are easily insurable as long as weather-index insurance is applied. Room for adverse selection can only emerge if the premium calculation is based on meteorological data that does not exactly represent the rainfall pattern of the insured area. In regions like microclimates where rainfall patterns vary highly, farmers tend to have a pretty good sense of how much rainfall they can expect. This could lead to cases in which only those farmers who know that the rainfall in their region lies significantly below the amount on which the premium calculation is based will purchase insurance. In the case of index-based insurance, indemnity payments depend only on the amount measured at the nearest weather station – and not on the actual loss. This is why adverse selection cannot affect the insurer's solvency if weather-index insurance is applied (Hess 2007, 388). If rainfall varies highly within one region, however, index-based insurance creates too much basis risk and is not viable.

As the losses caused by drought are not *determinable and measurable* at low cost, they have to be approximated by an index. As has already been demonstrated, it is expensive for full-service micro-insurance providers to go out to assess the veracity of each insurance claim. This is especially true for risks associated with drought, since losses will be reported repeatedly and not all at the same time. Therefore, the condition of a determinable and measurable loss can only be fulfilled with high transaction costs. Index-based insurance is the more viable option for covering this risk because it approximates the losses instead of assessing them on the ground.

Risk pooling is possible for drought risk. But as most droughts affect large areas at the same time, drought risk has to be pooled internationally, either through the purchase of reinsurance or through weather derivatives (Nguyen 2007, 237). Full-service insurers are generally better equipped to purchase international reinsurance. As the criteria for indemnity payment are more transparent for index-based insurance than for traditional crop insurance, access to reinsurance will be easier and cheaper for the former (Hess et al. 2005, 17–18).

Whether insurance is the most *adequate risk-management strategy* with regard to the risks of crop losses or livestock death depends on the probability of drought and its severity. For some regions, the probability of drought might be so high that it is not economically feasible to produce or even to live there. Not even insurance can change this. However, in regions where the probability of drought is relatively low but the associated losses are severe, insurance is probably the most adequate risk-management strategy.

Although most insurability conditions are fulfilled for drought risk, some caveats remain. The following case study shows how essential it is to take these into consideration if index-based weather insurance is to be provided.

Case study: Rainfall-index insurance in India
The weather-index micro-insurance provided by BASIX in India offers some helpful insights with regard to the insurability of drought risks in micro-insurance. The experience of this scheme largely represents that of other insurance schemes around the world. The scheme has been operating since 2003, with the number of policies sold steadily increasing (Hess et al. 2005, 96). The scheme operates in cooperation with the national insurance company, ICICI Lombard, and has received technical advice from the World Bank. In the theoretical analysis, three caveats to the insurability of drought in micro-insurance have been identified. This case study provides some clues to dealing with them. First of all, it was shown that the necessity of purchasing reinsurance increased premium rates and reduced demand for the product. In the Indian case, reinsurance was purchased from the very beginning despite the relatively low share of rainfall insurance in the insurance company's whole portfolio. Since first-year indemnity payments were made on the basis of the threshold levels recorded by national weather stations that have provided complete time-series data since the 1960s, it was possible to purchase reinsurance for the contracts with national-reference weather stations. As BASIX and ICICI Lombard tried to increase the outreach of their program and reduce basis risk, in the following years, more weather stations were considered. These, however, were managed by regional authorities and did not fulfil the high standards of the reinsurers with regard to providing complete time-series data. Therefore, the reinsurance itself was designed as index insurance that only took into consideration the rainfall levels measured at the national meteorological stations (Giné / Townsend / Vickery 2010, 11). This case study shows that it is very possible to purchase reinsurance for rainfall-index insurance, but that if this reinsurance is based on an index, the national insurer also will have to bear the emerging basis risk, which further raises premiums and reduces the insurance benefits. Second, the premium rates in drought-prone areas can be prohibitively high, making it impossible to sell insurance in these areas. This was observed in the case study. After calculating the exact premium for each region, BASIX and ICICI Lombard had to reduce the premium rates in some regions, since the high rates in drought-prone areas made the insurance product inaccessible (Bie Lilleor et al. 2005, 11). Since 2008, public subsidies also have been available for commercial agricultural insurance, which has led to the reduction of premium rates in many regions. This political instrument highly increases accessibility of drought insurance, although it does not change the underlying cause for high premium rates: If drought risk becomes too high, production in the threatened areas is unsustainable. Finally, keeping basis risk to a minimum has been identified as a critical condition for offering drought index-insurance. As basis risk was relatively high in the first pilot project, in subsequent years policies were only sold for the area within a radius of 20 km of a weather station. This clearly limited basis risk and increased customers' confidence in the product (Giné / Townsend / Vickery 2010, 14) – but also reduced the number of policies that could be sold.
Source: Own compilation

The theoretical analysis and the case study clearly reveal that it is possible for full-service insurers to provide micro-insurance that covers drought risk. However, since accessibility greatly depends on premium levels, it can be politically desirable to subsidise micro-insurance in drought-prone areas.

4.2 Hail

Hail can cause huge losses to harvests and damage infrastructure, real estate and movable property. The damage caused by hail is mostly confined to a relatively small zone that in most cases does not exceed a few hundred square meters. But there is little protection against the damage because it occurs within only a few minutes. In this regard hail resembles storms and typhoons, which also cause damage within short time spans and in relatively small zones. As with hail, there is little protection for crops against storms and typhoons.

Except for tropical zones, the whole world is exposed to the risk of hail (Munich Re 2009). Hail risk is therefore included in most traditional agricultural multi-peril crop micro-insurance. However, since most of these schemes depend on significant subsidisation, it remains unclear how well these schemes cover hail risk; to the best of my knowledge, no market-based micro-insurance for hail risk exists in developing countries.

Hail belongs to the natural risks that are insurable in micro-insurance, although in practice, it is not covered by market-based schemes. The diversification of the risk at the national level helps keep premiums low. But in order to make hail insurance profitable, innovative products are necessary. Hail risk can only be covered by micro-insurance if the insurer can assess many claims at the same time. To guarantee this, group-insurance contracts need be developed. The following sections address these issues in more detail.

Harvest losses and property damage caused by hail are *accidental and unintentional*. Therefore, hail risk fulfils the first condition for insurability. The probability of loss is not susceptible to manipulation because measures for protecting immovable property and crops against hail are very rare and expensive (Roberts 2005a, 37; Kang 2007, 3).

Calculating the chance of loss for crops is straightforward: The insurer needs access to information about the probability and severity of hailstorms and also has to assess the insured crops' vulnerability to hail. Premium calculation is more costly for property insurance, since the extent of property damage depends both on the severity of the hailstorm and the construction material of the insured property (Munich Re 2009). This limits the insurability of property damage in micro-insurance.

Adverse selection is not a consideration in hail insurance. The probability and severity of – as well as the vulnerability of the insured objects to – hail are objectively assessable. In order to save costs, the insurer can conduct the *risk classification* based on information collected from the policyholder about construction materials, type of crops planted, etc. Because the insurer cannot assess the veracity of this information at the time of contract underwriting, but can during loss assessment, a clause can be added to the contract that states that the indemnity payment will be rejected if the information about the nature of the insured object turns out to be wrong.

Usually the damage zone of a hailstorm is relatively confined. If the loss assessment is realised soon after the hazardous event, the cause of loss is easily identifiable (Mahul / Stutley 2010, 33–43). If group insurance is provided, *all losses within the damage zone can be determined and assessed* at the same time. This allows for a significant reduction of the transaction costs that ensure the insurability of the risk – but to make this possible, innovative products must be developed. Currently, large insurance companies prefer to provide index-based micro-insurance that is easier to manage, with underwriting and loss adjustment procedures that can be standardised. For hail insurance, loss assessment still requires on-the-ground visits, which reduces the attraction of this product for many insurance companies. Group insurance that combines the advantage of reduced transaction costs (because of the need to make only one trip to the affected zone), with individual loss assessment, could be a viable option in this context.

While the damage zone of hailstorms is not very large, it is still large enough to impede *risk pooling* at the community level (Gurenko / Mahul 2004, 3). The risk needs to be diversified nationally, but there is little need for reinsurance.

Insurance is the *most adequate risk-management strategy* with regard to harvest losses and to damage to immovable property because there are no effective, cost-efficient alternatives for managing these risks. Movable property is not insurable because the risk of damage can be avoided by storing the property. Demand for micro-insurance will probably mainly exist for crops only, since property insurance can be relatively expensive and is mostly acquired to protect valuable and highly vulnerable objects like glasshouses or solar collectors. But the micro-insurance target-group members usually don't own such objects.

Hail risk is insurable in micro-insurance as long as innovative products, such as group insurance, are offered.

4.3 River flood

Living and producing in coastal areas and close to rivers has several advantages. However, unexpected floods can cause considerable damage to agricultural production, property and infrastructure and therefore pose a constant threat to residents. As with volcanic eruptions, floods and tsunamis, the river-flood risk zone is relatively small and easily identifiable. Since only small groups of the population will seek protection against this risk, it is especially difficult to form a sufficiently large risk pool.

Flood is the natural hazard that affects most people in developing countries, accounting for 62 percent of all people affected by natural disasters between 1991 and 2005 (CRED 2011). The risks related to flood, and river flooding in particular, are the risks of property damage and of agricultural-production losses. In spite of the huge relevance of flood risk to the lives and livelihoods of many people, it was not possible to find any flood micro-insurance currently being offered in developing countries.

Due to data constraints, in many developing countries micro-insurance cannot cover river-flood risks. While technological progress makes the risk of crop losses insurable for full-service insurers, this is only possible where very detailed topographic data exist that allow for accurate modelling of risk zones. But these data do not exist in many developing countries. Property damage cannot be offered by micro-insurers, because loss assessment is too costly and the high costs of assessing the vulnerability of the insured objects make premium calculation too expensive. A detailed analysis of the insurability of flood risk follows.

For crops and other immovable property the condition that *the loss has to be accidental and unintentional* is generally fulfilled. As with most natural hazards, the incidence of river floods is beyond the control of the insured. While human intervention can influence the severity of floods – for example, through dams or the controlled flooding of agricultural areas in order to protect cities – these interventions are mostly publicly organised and cannot be influenced by the individual policyholder. Insuring movable property, however, requires deductibles, because the policy could otherwise provide incentives to reduce efforts in loss mitigation (Citlak / Wagner 2001, 99).

Calculating the chance of loss is generally possible for river-flood risks. For the risk of crop losses, this is less costly because of crops' high vulnerability to floods. But pricing the premium for property insurance is generally more complicated, since the potential damage depends on the duration and level of inundation, as well as on the vulnerability of the construction material (Swiss Re 1998, 23–25). It is possible to model the duration and

level of inundation, but it requires detailed information about the terrain and hydrological characteristics in the region of interest (Lotsch / Dick / Manuamorn 2010, 47–49). If this information is not available, the risk cannot be covered by micro-insurance. The expected damage also depends on the insured object's vulnerability to flood. This requires detailed information about construction materials, in the case of property damage, and about the stage of crop growth, for crop insurance. Calculating the chance of loss is much less costly for the risk of agricultural-production losses – but insuring both risks is feasible.

The main problem in covering river-flood risks by micro-insurance is *how to classify policyholders in terms of risk zones*. Detailed topographic information is required in order to identify flood-risk zones. If this information is not available, adverse selection may jeopardise the insurer's sustainability. Farmers who have already experienced floods generally know which areas are exposed to floods and which are not. They may therefore choose to buy insurance only if they are sure of being flooded regularly. This in turn will push the cost of claims and indemnity payments above the calculated value. Nevertheless, adverse selection jeopardises insurability only for traditional crop insurance that assesses losses on the ground and for more sophisticated index-based insurance products that rely on remote sensing to approximate losses. Index-based insurance will not face adverse selection problems if indemnity payments depend on less precise triggers, such as water gauges.[5]

Determining and measuring the loss caused by river flood requires expensive on-the-ground assessment for immovable property, but can be approximated by remote sensing for agricultural-production losses. For damage to real estate, experts need to assess possible long-term damages in construction, which makes loss assessment particularly expensive for immovable property insurance (Swiss Re 1998, 19–20). Movable-property damage can also be assessed, albeit at relative high cost. But since the complete loss of the object cannot be verified, movable property is not insurable. Crop losses, meanwhile, can be approximated using satellite remote sensing, which can be significantly cheaper than on-the-ground assessments (Lotsch / Dick / Manuamorn 2010, 49). Group insurance could be another option for insuring crop losses. Since severe floods will affect almost all the farmers in a region, it is possible to reduce the cost of loss assessment by assessing many claims at the same time.

Forming a *sufficiently large risk pool* for flood risks is particularly difficult because the risk is covariant and because risk zones are relatively small. Therefore only those groups who live or produce close to rivers and coasts seek insurance, while the majority of the population has no interest in such a product (see e.g. Swiss Re 1998, 30–32). As river floods often hit not just one region, but several regions at the same time (for example, in the aftermath of exceptionally snowy winters) risk pooling on a national level is impossible. Reinsurance or government guarantees are necessary to ensure the financial sustainability of the insurance company that offers flood-risk micro-insurance.

Micro-insurance can significantly improve the flood-risk management of agricultural producers. Despite the increased risk of crop loss in river basins, it may still be viable to produce in such areas because the soil productivity is much higher in river basins than in other areas. As long as the probability of river floods is not too high, insurance is the most

5 In that case, though, basis risk is so high that the insurance hardly seems to be an appropriate risk-management strategy.

adequate risk-management strategy for the risk of crop losses. However, insuring immovable property against flood risk in micro-insurance is not viable. In most cases, it would be much less costly to not build in flood-prone areas.

Case study: River-flood insurance in Indonesia
The case chosen for flood risk is the flood insurance sold by Munich Re, the GTZ and Asuransi Wahama Tata in Jakarta in 2009. To the best of my knowledge, this was the only market-based micro-insurance that covered flood risk. The insurance was designed as index insurance, triggering one and the same payout for all insured if the water level at the Manggarai Flood Gate in Central Jakarta exceeded 9.5 m (Rohregger / Rompel 2010, 306). With the innovative design of this insurance, the GTZ and its partners overcame several obstacles faced by traditional flood insurance, making the product accessible even to the low-income population. Uptake has been very low, however: In the first month, about 50 policies were sold and sales did not significantly increase after that (White 2011, 22). This is probably why the scheme was discontinued in 2010. The low uptake can partially be explained by the difficulties in insuring flood risk that were previously identified. Several objections were revealed to insuring flood risks in general and the risk of property damage in particular. The first general objection to insuring flood risks was the risk of adverse selection. It has already been stated that detailed topographic information is required in order to identify flood-risk zones and classify policyholders. This difficulty was circumvented by the GTZ because the predefined payout was the same for all policyholders and only depended on the water level. This, however, dramatically increased basis risk. Second, forming a risk pool large enough to cover the losses had been identified as possible problem. But with the GTZ including Munich Re in the project design and pricing from the beginning, access to reinsurance was guaranteed. The objections against insuring property damage in particular were the costs of loss assessment and the difficulty of calculating exact premium rates if the vulnerability of the insured objects was to be taken into account. The GTZ and its partners tried to avoid high costs by offering an index-based insurance. But by doing so, they introduced a very high basis risk that basically transformed the insurance into a lottery. The insured were faced with great uncertainty since they did not know if they would be indemnified in case of flood (at least as long as the water level remained below the trigger), or if the payout would to any degree match the damage.
Source: Own compilation

There are many caveats to covering flood risk by micro-insurance. While some of them can be overcome by technological innovations and exact topographic data, insurability is still limited to agricultural-production losses, which could be covered by full-service insurers. Micro-insurance's impossibility of covering property damage caused by flood has been confirmed by the findings of this case study. It also showed once again how important it is to limit basis risk in order to gain the trust of potential policyholders.

4.4 Livestock diseases

Livestock diseases can cause severe losses in livestock production and reduce revenue when only parts of the production can be sold, or when prices fall drastically due to epidemics. Furthermore, they can tremendously increase on-farm costs due to obligatory quarantine, curative or preventive measures. In many cultures, livestock represents the wealth of a family; their loss leads to diminished food intake, malnutrition and increased poverty. If the losses are too high, economic recovery from the shock will be impossible without external assistance. For producers, losses in livestock production can lead to a significant reduction in income, and in extreme cases, even cause the producer to become

insolvent. It is therefore essential for livestock producers and herders to efficiently manage the risk of livestock losses due to disease. The significance of livestock diseases in agricultural production is also reflected in the fact that livestock insurance makes up almost 50 percent of agricultural micro-insurance (Roth / McCord 2008, 30).

Due to several constraints, most livestock diseases are not insurable in micro-insurance. For many diseases, other risk-management strategies are more adequate. Diseases that are difficult to prevent and not too contagious are insurable, but only if transaction costs can be kept to a minimum. This can be achieved if the insured have direct access to veterinary services and the risks are covered by community-based schemes. The various arguments, grouped by insurability conditions, are explained in more detail in the following sections.

The first condition, *accidental and unintentional loss*, is rarely fulfilled for livestock diseases because many of them are partially or totally preventable by sound husbandry, livestock sanitation and vaccination programs (Roberts 2005b, 31). Moral hazard can lead to fewer efforts at preventing disease and limiting contamination because in most cases, the insurer cannot observe the preventive measures of herders and livestock farmers. Obviously, the insurer can set minimum requirements for hygiene and vaccination in the policy. But while providing proof for vaccinations is relatively cheap, ascertaining whether minimum hygienic standards are met requires regular on-site inspections. This increases transaction costs and limits the insurability of livestock-disease risks in micro-insurance. Introducing deductibles might be an option to solve this dilemma, although it could reduce demand significantly depending on the market structure. It is therefore probably more cost-efficient to insure only diseases that cannot result from mismanagement or poor sanitation.

Calculating the chance of loss for livestock diseases is especially difficult, since most countries don't keep reliable records of disease outbreaks. Diseases are often not reported at all – or wrongly – thus obliging the insurer to estimate the respective probabilities (Dufhues / Lemke / Fischer 2004, 3). Moreover, many diseases are curable; although they do not cause the loss of an animal, they do increase on-farm costs. If the insurer is willing to cover curative measures, they must also be calculated.

Risk classification for livestock-disease risks is generally possible. Nevertheless, certain diseases are more common in some regions than in others. This can be due to a range of factors, such as geographical location, proximity to fresh water, presence of mosquitoes, etc. (Coble et al. 2006, 259). If asymmetrical information allows the policyholders to better assess the probability of disease outbreaks than the insurer, this can result in adverse selection. One should expect however, that the objectivity of the relevant data will allow the insurer to conduct an accurate risk classification. As has already been stated, individual farming practices highly influence the incidence of some livestock diseases, which makes risk classification more difficult. But since these diseases do not fulfil the "accidental and unintentional loss" criterion, they need not be further considered.

Determining and measuring the actual loss caused by livestock diseases can be costly. First of all, the insurer needs to assess whether the animal has actually died – and not been sold. This must happen quickly since contagious diseases spread rapidly if dead animals are not buried or burned immediately. Furthermore, it has to be determined if the disease that caused the death was covered by the policy. This makes on-the-ground verification and veterinary examination indispensable (Roth / McCord 2008, 30). If the necessary in-

frastructure is available, that is, if the insured has access to veterinary services, this condition can be fulfilled. If not, this risk is not insurable. To be able to verify the veracity of the claims, there should be no social or geographic distance between the insured, the veterinarian and the insurer. This is why livestock diseases can be more accurately insured at the community level.

Whether *risk pooling* for livestock diseases needs to take place at a regional, national or international level depends on the characteristics of the insured diseases. Only insurance companies that operate nationally or internationally can diversify highly contagious diseases, whereas it might be possible to insure less contagious diseases at the community level. Since moral hazard and fraud can best be avoided in community-based schemes, it seems advisable to insure mainly idiosyncratic diseases in micro-insurance.

Micro-insurance can only cover diseases that are neither preventable nor curable. For curable or preventable diseases, risk prevention through sound husbandry, vaccination and hygiene is the *adequate risk-management strategy*. For other diseases, insurance could be a viable option.

The insurability of livestock-disease risks in micro-insurance is challenged in many aspects. The following case study shows that the caveats seriously challenge micro-insurance provision for livestock diseases.

Case study: Livestock-disease insurance in Vietnam

The case to be analysed here is the project "Programme Fleuve Rouge" that was started in Vietnam in 1999 by the French NGO, GRET (Groupe d'Échange et de Recherches Technologiques). It is an interesting case insofar as it was one of the few livestock insurance schemes that specifically tried to avoid some of the problems of traditional agricultural insurance by creating community-based schemes.

The project aimed at insuring livestock farmers in Vietnam against some common pig diseases by creating community-based insurance schemes while also increasing local knowledge on sanitation and husbandry. The main objective was to reduce the risk of income losses due to livestock diseases. To that end, GRET opened veterinary offices that provided advice and veterinary services to the insured, and offered policies covering the most common pig diseases.

With regard to the difficulties already outlined in covering livestock disease risks in micro-insurance, this case study provides the following insights.

The first criterion states that the disease outbreak must be difficult to prevent. By ignoring this criterion, GRET underestimated the possibility of declining demand for the insurance product. While the outbreak of the insured diseases is not a result of inadequate sanitation and hygiene, they are nevertheless all preventable through vaccination. Since the insurance contract made vaccination against the insured diseases obligatory, and verified this in case of loss, it was possible to insure against these diseases. The probability of contamination could not be totally excluded, so the policy also covered the cost of treatment for the insured diseases and provided indemnity in case the animal died (Dufhues / Lemke / Fischer 2004, 27). In the course of the project, the incidence of piglet deaths dropped dramatically from 16 percent per annum to 3.5 percent – thanks to improved husbandry practices and vaccinations (Lamballe / Rosner 2005, 30). This is why, after GRET concluded its work, the main focus of many community-based insurance schemes shifted from offering insurance to providing cheap veterinary services to its members. This shows that because these diseases are preventable, insurance is not the most adequate strategy to manage these risks.

Second, it has been stated that in order to be manageable at the community level, the insured diseases should not be too contagious. As pig diseases are rarely epidemic, the scheme introduced by GRET could work on a community basis (Hung 2010, 52). This would be much more difficult to realise for other livestock diseases.

Case study: Livestock-disease insurance in Vietnam (cont.)
Finally, the case study shows that if livestock diseases are to be covered, the insured need to have direct access to veterinary services. In the project designed by GRET, veterinary services played a key role, not only in providing vaccinations and determining the cause of death of the insured animals, but also in providing counselling and advice to the policyholders. In Vietnam, health workers were perfectly capable of fulfilling the tasks, which shows that the call for fully-trained veterinarians might be exaggerated. Training health workers was one of GRET's tasks. Their crucial role was revealed by the fact that some of the insurance schemes had to stop functioning after the health workers resigned (Roth / McCord 2008, 25).
Source: Own compilation

The theoretical analysis and the case study of livestock-disease insurance in Vietnam clearly show that while community-based schemes can cover livestock diseases in micro-insurance, it is not always adequate risk-management strategy. As livestock sanitation improved and vaccination became more common, the demand for insurance decreased drastically. For many diseases, the risk of contamination can be reduced through preventive measures. It is therefore in the insurer's interest to educate the insured in preventive measures, since they lead to a reduction in the number of insurance claims. But this in turn reduces the demand for insurance – and is the reason many insurers refrain from offering livestock insurance. While it should be up to the Government to provide technical advice to farmers and herders, this could be an interesting field for donor and NGO involvement if the State is not able or willing to do so.

5 The conclusion and the way forward

It has been shown that many, but not all, natural risks can be insured in micro-insurance. The analysis has further revealed that the best scheme for providing micro-insurance varies according to the risks to be insured. Applying the framework to four natural risks gave the following results:

Full-service insurers can cover losses in livestock and crop production resulting from drought as long as the losses can be accurately approximated by an index. If the basic risk becomes too great, however, micro-insurance is no longer an adequate risk-management strategy. Also, the cost of reinsurance should not become too high. The case study clearly shows that in high-risk areas, external subsidisation of premiums is indispensable to keep insurance affordable. While this may be politically desirable, from a risk-management perspective, production is not viable in areas with high drought probability and should be completely avoided.

Hail was found to be insurable as long as a single company insures several policyholders within one region. As hail insurance requires on-the-ground loss assessment, transaction costs can only be kept relatively low if the insurer can assess many claims at the same time. Group insurance could be an interesting option to achieve this. Real estate and movable property damage from hail were found not to be insurable in micro-insurance.

Theoretically, full-service insurers can cover river-flood risk. The mapping of risk zones, however, requires exact topographic data, which, due to data constraints in many developing countries, limits the insurability of river-flood risks. Losses can either be assessed on

the ground, which then makes it necessary to insure several policyholders within the same region, or can be approximated via satellite remote sensing. It was also shown that only crop losses are insurable in micro-insurance.

Livestock diseases, finally, are not easily insurable in micro-insurance. First of all, the diseases covered by micro-insurance should not be preventable by either vaccination or sound husbandry. Further, insurability conditions are only fulfilled in cases where the risk of contamination is low and transaction costs can be kept to a minimum. Therefore, only a few diseases are insurable, and in order to guarantee immediate loss assessment these diseases have to be covered by community-based schemes.

The implications for the provision of micro-insurance for natural risks have been demonstrated as follows: The degree of covariance of risks is decisive regarding how a particular risk should be insured. Idiosyncratic risks are most likely to be insurable at the community level. For managing highly covariant risks that are likely to hit whole regions or even entire countries simultaneously, contracts must be pooled nationally or internationally. This can best be done by large insurance companies. In such cases, loss assessment becomes especially important. If losses cannot be approximated by an index, they must be assessed on-the-ground, which can only be done cost-efficiently for a very few risks, such as hail or flood.

Despite the fact that many natural risks can be covered by micro-insurance, there is still room for improving the outreach and efficiency of micro-insurance for natural risks by creating a new micro-insurance scheme. Most micro-insurance schemes are only able to cover one, or maybe two, risks – if they are not going to need a lot of external subsidisation. That requires the insured to purchase different insurance products from different micro-insurance providers, which is inefficient and time-consuming. An innovative micro-insurance scheme is needed to provide more comprehensive coverage without creating additional costs.

A comprehensive micro-insurance scheme for natural risks must combine the advantages of existing micro-insurance schemes. Two major schemes can provide micro-insurance for natural risks, each with comparative advantages: First, community-based schemes are especially successful in avoiding information asymmetries and can assess losses more cost-efficiently. Second, full-service micro-insurance providers have better access to know-how and reinsurance, and therefore can insure covariant risks and risks that require access to highly specialised data. With an innovative micro-insurance scheme that combines these advantages, a country can substantially increase the number of risks that can be insured by a single contract.

A promising way of organising such a comprehensive scheme would be a national micro-insurance scheme that incorporates community-based insurance schemes in a national umbrella organisation. In order to realise such a scheme, community-based insurance schemes need to be created, and an organisation able to fulfil the tasks of the national umbrella – possibly a national insurance company – needs to be identified. The community-based schemes have to be cooperatively managed and are responsible for the underwriting process. They also need to retain a certain part of the premium in order to directly assess and adjust part of the losses. The national umbrella is responsible for coordinating, supporting and reinsuring the community-based schemes. This umbrella can be publicly or privately organised. It needs to have extensive actuarial know-how and be willing and able

to closely cooperate with the community-based schemes in order to support them and provide technical advice.

In such a national micro-insurance scheme, idiosyncratic risks could be covered by the community-based schemes, while the national umbrella would be responsible for covering covariant risks. Idiosyncratic risks allow for risk-pooling within the community. Because community-based schemes offer the advantage of avoiding information asymmetries, these schemes can cover idiosyncratic risks that cannot be covered by a national insurance company. Covariant risks need to be insured by micro-insurance schemes that can pool risks over a larger group. The national umbrella organisation functions as a reinsurer for the community-based schemes, and is responsible for insuring risks that affect many policyholders simultaneously. These risks can be covered either through index-based insurance or group insurance. The provision of index insurance follows the same principles as in the full-service insurance scheme. With group insurance, although the national umbrella needs to assess the losses on the ground, it can significantly reduce transaction costs by assessing many losses at the same time. The umbrella organisation would also purchase international reinsurance or benefit from Government guarantees.

By combining the advantages of existing schemes, this comprehensive micro-insurance scheme would be able to cover a wider range of natural risks. This scheme could cover idiosyncratic risks such as certain pests and diseases, as well as covariant risks such as hail, storms, river floods, tsunamis and landslides. Droughts and fluctuations in temperature could still be covered by index-based micro-insurance. The scheme would not only be able to combine those risks that already have been insured in micro-insurance in a single contract, but would also be able to extend the range of insurable risks to include risks such as hail and storms that are theoretically insurable in micro-insurance, but for which no coverage yet exists.

The inclusion of insurance and micro-insurance as tools for enhancing the adaptation to climate change in the Cancún Agreement of the UNFCCC creates important momentum for the implementation of micro-insurance for natural risks. This paper reveals that there are still significant improvements to be made in terms of coverage and cost-efficiency. This paper also offers initial suggestions about how to apply innovative micro-insurance schemes and products.

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