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Index-based insurance for climate risk management and rural development in Syria

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Abstract

Improving the adaptive capacity of rural producers to climate and weather risks may become an urgent issue in the early stages of political stabilization in the future. Therefore, this study analyses ago-ecological, economic and social benefits and institutional challenges for establishing index-based insurance markets to catalyse rural development in Syria. The paper examines the risk minimization potential of three index-insurance schemes: (1) a statistical index, (2) an agro-meteorologically based index and (3) a remote-sensing based index. It also discussed the contribution of index-based insurance markets to rural development in scenarios of increasing climate risks.

The study identifies a very high potential of all three insurance schemes to cope with increasing climate risk. Insurance schemes designed according to these indexes performed very well in terms of covering revenue losses in most of the extreme drought years observed in the country. Farmers purchasing an insurance contract may have better access to credits and have more comfort investing in agricultural production and improve the productivity. Low operation costs of such alternative index-based insurance programs make the financial tool more affordable to poor farmers and thus provide an excellent potential contribution to economic growth of rural areas.

Keywords: climate change, rainfall deficit, NDVI, income stabilization, food security

1. Introduction

The population of Syria surpassed 20 million in 2011 (World Bank, 2013). Agriculture employs 30 % of the population and contributes approximately 26 % to the country's GDP (UN, 2008). Syria has a land area of 185.518 km² of which 32 % is arable land, and 45 % is rangeland. Less than 25 % of the arable land is irrigated, while the remaining land, around 3258 thousand ha, is under rainfed agricultural production (Wattenbach, 2006).

The economy of Syria was in transition from a centrally planned to a market economy (Huff, 2004) before the political conflict started in 2011. Agricultural production is mainly carried out by small private farms. The role of the state is considered to be very high. It indirectly controls[1], for instance, the agricultural production through input- output subsidies and procurement policies (De Corte *et al.*, 2007; Ahmed *et al.*, 2010). The guaranteed output prices of the state prioritized crops were often higher than the world market prices (Huff, 2004). The state gives quotas for fixed maximum production according to national planning, and purchases these crops from smallholder farms with attractive output prices. The state subsidy packages differed from crop to crop. Cereal production is notably the most important activity in Syria which is stimulated by the state and occupies almost 65 % of the arable land (NAPC, 2005; Yigezu *et al.*, 2013). Cotton is another crop with a very attractive subsidy package and therefore widely spread in terms of area and total production (Ahmed *et al.*, 2010).

A price guarantee obviously reduces the market risk for wheat production to some extent. However, an increased production risk associated with climate change – higher temperatures and increasing frequency of below-average rainfall– is becoming the heaviest burden of Syrian farmers. Government price subsidies can no longer solely provide for complete securitization under increasing production volatility. In contrast, a fixed price policy reduces the natural hedging effect associated with price yield correlations (i.e. price and yield risk tends to cancel each other out). There is a very high uncertainty about the developments in agricultural policies in Syria due to the current conflict and the fact that vulnerability to climate change could be further aggravated in post conflict years as observed in the neighbouring regions (Mason *et al.*, 2011). Therefore, investigating the options of increasing the risk-coping potential of Syrian farmers is urgently needed in order to improve the livelihoods of farmers and food security in the country in the post conflict years. A crop

[1] The present tense is used for simplification reasons according latest available information, information about the state role in 2011/2012 vegetation season cannot be verified

insurance program could be a potential market-based financial instrument to increase the risk-coping capacity of farmers and agricultural lenders in Syria. The establishment of a crop insurance program was considered more than 20 years ago, but was not implemented due to high costs (Huff, 2004). Recent developments in insurance show index-based insurances suitable for developing countries and could allow implementing insurance programs with lower costs, and therefore need to be considered in Syria.

Although many studies discuss the large benefits of insurances in the development domain, the index-based insurance is a relatively new product in most markets. India has had a large area-yield index-based insurance scheme for around 20 million farmers for around 15 years, and Mexico has successfully implemented a weather index-based disaster assistance scheme for around 1 million farmers in 2007 (Mahul and Stutley, 2010). Alberta and Ontario, Canada have had successful area-yield and weather-index and even NDVI index-based forage insurance schemes (World Bank, 2005). Since 2005, African countries have started building weather index-based insurance schemes as well, notably Malawi, Kenya, Ethiopia, Tanzania and Rwanda.

Despite this growing importance, adaptation of index-based insurances is limited to about 36 cases only (IFAD and WFP, 2010). Empirical benefits and costs of index-based insurance may largely depend on farmers understanding and the agro-ecological and socio-economic condition of the concerned country (Barnett and Mahul, 2007; Patt *et al.*, 2010; Miranda and Farrin, 2012). The potential gains from insurance markets and constraints for developing such services for the conditions of Syria so far have not been investigated. Therefore, the objective of this study is to examine the bio-physical suitability, economic potential and institutional trade-offs of an index-based insurance in the rainfed farming systems of Syria.

2. Climate risk in Syria

The climate of Syria is Mediterranean, semiarid (west and north of the country) to arid (east and south of the country), with rainfall during winter and a 5-7 month dry season during summer. The rainfed cropping season usually begins in November and extends to May-June. Terminal droughts are frequent. In accordance with the different rainfall levels, Syria has been divided into five farming systems, so called stability zones (Szõnyi et al. 2005; Figure 1). The main agricultural production areas are located in the Zones 1, 2 and 3.

<location of Figure 1>

FUGURE 1 Agricultural stability zones in Syria; *source: Szõnyi et al. (2005)*

Zone 1 is the most favourable for rainfed farming with annual rainfall of more than 600 mm in Zone 1a and 350-600 mm in Zone 1b. Rainfall in Zone 2 and Zone 3 is between 250-350 mm. Zone 4 is suitable for barley, which is mainly used as animal feed (Breisinger *et al.*, 2011). Zone 5 is not suitable for rainfed cropping and used only for grazing. This area is very sparsely vegetated (Figure 2) due to low amount of rainfall and marginally used for agricultural production (Ahmed *et al.*, 2010).

<location of Figure 2>

FUGURE 2 Main agricultural zones in Syria; *source: Celis et al. (2007)*

85% of the rainfed area belongs to Zone 1 and 2 (Yigezu *et al.*, 2013). Figure 3 demonstrates the importance of these two zones in terms of contribution to total national wheat production.

<location of Figure 3>

FIGURE 3 Rainfed wheat production (Mg/yr) in different zones of Syria; *source: NAPC (2010)*

High inter-annual variation of rainfall is the main risk source for agricultural producers in Syria. Droughts in the years 1999, 2007 and 2008 were reported to be the worst in recent history. The average country level yields of wheat, barley, lentil and chickpea reduced by 78.9 % in the rainfed areas due to drought in the 2007/08 season (UN, 2008 compare Figure 3). The eastern parts of Syria were most severely impacted and grain yields were almost zero (UN, 2008). In total, more than 150,000 households in Syria (around 750,000 people) faced a complete harvest loss. Small-scale farmers are often the people worst effected and droughts have spill-over effects in the subsequent cropping season when these farmers lack the financial means to buy seeds and other inputs (Wattenbach, 2006). The share of agricultural income in the total household income is reported to be as high as 52% in some regions of Syria (Rovere *et al.*, 2006). More than 50% of the household income is spent on food expenses which makes the access to food very difficult during drought years when agricultural income drops (Breisinger *et al.*, 2011). Traditional risk management options such as crop diversification and community based loans often fail due to severity of the drought. The government provided disaster relief measures in a form of loans and food rations but the need for assistance was beyond the capacity and resources of the government (UN, 2008). Improved irrigation options (e.g. sprinkler) have been shown as the best technical solution to cope with increasing sequence of droughts and depleting stock of groundwater in Syria (Oweis *et al.*, 2011; Yigezu *et al.*, 2013). However, implementation of such novel technologies remains limited due to a lack of credit for such new initiatives (De Corte *et al.*, 2007).

The studies conducted in the region project an increase in temperature (see Figure 4) and higher rainfall variability in the future (e.g. Oweis *et al.*, 2011). The same study simulates wheat yields under projected climate change scenarios and predicts higher inter-annual variability of yields in the future than currently observed.

<location of Figure 4>

FIGURE 4 Linear trends of 'present' (black) and future (grey) average annual temperature[2] estimated by the bias-corrected ENEA model output for Aleppo region (36.04 °N 37.10 °E); *Source: adapted from Oweis et al. (2011)*

Thus, available studies already indicate even higher yield volatilities in the future which may increase the vulnerability of rural populations further. Therefore, new policies for improving the risk coping potential are needed and several studies discuss the need for insurance programs to protect capital losses of poor populations and improve productivity in a sustainable way in Syria (Huff, 2004; Wattenbach, 2006; Breisinger *et al.*, 2011).

3. The role of index-based insurance to foster rural development

Traditional insurances have been shown to be very ineffective in developing countries, while on the other hand index-based insurances were recommended as a suitable risk management instrument (Hess *et al.*, 2002; Glauber, 2004). Farmers receive indemnity when the specified index falls below (or above) a certain value. Most index insurances are based on weather indexes, which are highly correlated to local yields. Index insurances[3] address factors beyond farmers' control. This helps to eliminate the problems of moral hazard and adverse selection. It also decreases the costs for insurance companies by reducing the need for field visits (Bryla and Syroka, 2007).

Studies from developing countries with similar conditions to Syria discuss several positive contributions of index-based insurances on the development of the rural areas (Roberts, 2005; Barnett and Mahul, 2007; Chantarat *et al.*, 2008; Skees, 2008; Hazell and Hess, 2010; Mahul

[2] Average temperature in the graph is estimated as $T_{avg} = (T_{max}+T_{min})/2$
[3] Index-based insurance and index insurance terminologies are used interchangeably with the same meaning

and Stutley, 2010; Nieto *et al.*, 2010; Miranda and Farrin, 2012). There is a lack of sufficient financial resources to invest in technological improvement at the farm level as well as at the agricultural sector level in many developing countries such as Syria. Risk-averse farmers in general prefer to spend less on agro-inputs, such as fertilizers or improved seed varieties when confidence about the returns of such investments is low (Barnett et al., 2007). Agricultural insurances against yield loss allow risk to be transferred to agricultural insurance markets and thus increase the confidence of farmers and facilitate their investment in agricultural production in general (Bryla and Syroka, 2007). Enabling the access of poor households to credits is another potential contribution of insurance of rural development (Roberts, 2005). Poor farmers prone to climate risks often have lower chances of lending since banks are concerned about the inability to repay loans (Hazell and Hess, 2010). Credit institutes are more willing to provide agricultural credits to rural households and farmers that have index insurance since producers could use indemnity payments as credit collateral (Skees, 2008). Therefore, index-based insurance offer not only benefits of farmers but also supports the state objective of maintaining grain self-sufficiency in Syria.

Chantarat *et al.* (2008) and Hellmuth *et al.* (2009) revealed that insurance programs established according to rainfall based drought indexes have a very high correlation with food assistance in developing countries. Therefore, proper design of agricultural insurance programs could improve food security under conditions of systemic droughts (Chantarat *et al.*, 2008). In this respect, index insurances can be considered as one of the social protection systems to cope with climate risks (Siddiqi, 2011). Therefore, agricultural insurance in developing countries may have a positive influence on agricultural production beyond merely securing farmers' profits (Hazell and Hess, 2010). This type of policy is very necessary in Syria where high volatility of agricultural income is causing serious challenges for development in rural areas.

4. Methodology

4.1. Estimation of risk premiums and indemnity payments

Finding the most influential hydro-metrological indexes is a prerequisite for developing weather derivatives for a region or a country. The hedging (risk minimization) potential of the index-insurance is higher when stochastic dependency between the weather index and farm income is high. Usually these indexes are rainfall and temperature based, and therefore often referred to as weather derivatives. They often take the form of option contracts (Berg and Schmitz, 2008), where payoff in case of long put option are expressed as:

$$A = VMax[0,(K-x)] \quad (1)$$

where the farmer receives payment equal to the difference (K-x) multiplied by the tick size (*V*) if the index (*x*) falls below the strike level (*K*). The fair premium (P_f) can be estimated by multiplying the expected value of the payoff (E(A)) by the discount factor (e^{-rd}) and can be written as:

$$P_f = e^{-rd}E(A) = e^{-rd}VE(Max[0,(K-x)]) \quad (2)$$

where r is the interest rate over the duration d.

Equation 2 can be estimated according to the burn analysis (Odening *et al.*, 2007) as:

$$P_f = e^{-rd}\left[\frac{1}{n}\sum_{t=1}^{n} A_t\right] \quad (3)$$

Establishment of index insurance product and identification of the fair premium demands three main steps: collecting long term yield and weather data; identifying the index value and payoffs for each year; and calculating an average payoff and discounting with the risk free interest rate (Odening *et al.*, 2007).

Total net revenue per hectare under conditions of purchasing the index-based insurance contract can be estimated as:

$$W_p = yp_y + VMax[0,(K-x)] - P_f \quad (4)$$

Identifying the index highly correlated with yields is the most important step in designing the index-based insurances and following chapter presents Syria as case the study for selecting suitable indexes.

4.2. Insurance index design

We examine the risk minimization potential of index-based insurance in the case of winter wheat production in northern Syria due to its importance in food security. Winter wheat, as well as all other major winter crops in northern Syria, is mainly cropped under rainfed conditions. Winter wheat is usually planted in November-December at the onset of the (winter) rainy season and harvested by the end of May, beginning of June. Data for the main wheat producing zones at the regional level according to stability zones was obtained from National Agricultural Policy Center (NAPC) of Syria for the years of 1985-2007 (NAPC, 2010).

Farm yield data was also was obtained for the research station of the International Center for Agricultural Research in the Dry Areas (ICARDA) located 30 km south of the city of Aleppo in northern Syria. Daily climate data was also available from the ICARDA weather station (*lat* 36°01´N, *long* 36°56´E; elevation: 284 m, Figure 5).

We considered the suitability of three different index design approaches to the conditions of northern Syria: (1) statistical approach, (2) agro-metrological and (3) remote sensing based indexes.

In the statistical approach, single weather station data from the ICARDA climate station is used together with the district level yield data for Aleppo region Zone 2. Several functional forms used by Vedenov and Barnett (2004) are tested after de-trending the yield data by fitting a log-linear trend model. The dependency of wheat yields from cumulative rainfall, monthly temperature and rainfall were tested. The following statistical function yielded the best fit to de-trended yield data (Y_{det}) for the given district:

$$\mathrm{Y_{det}} = \beta_0 + \beta_1 \mathrm{R}_{mar} + \beta_2 \mathrm{R}_{may} + \beta_3 T_{may} + \beta_4 \mathrm{R}_{\mathrm{apr}}^2 + \beta_5 \mathrm{R}_{\mathrm{may}}^2 + \beta_6 \mathrm{T}_{\mathrm{apr}}^2 + \beta_7 \mathrm{T}_{\mathrm{may}}^2 + \beta_8 \mathrm{R}_{\mathrm{may}} \mathrm{T}_{\mathrm{may}} + \varepsilon \quad (5)$$

where, $\mathrm{R}_{mar}, \mathrm{R}_{apr}, \mathrm{R}_{may}$ are monthly rainfall for March, April and May, $\mathrm{T}_{apr}, \mathrm{T}_{may}$ are monthly average temperatures for April and May.

The latest development in the field of index insurance is to use agronomically sound meteorological indexes which do not necessarily require yield records in the insurance design. Yet, the risk coping potential can be tested when yield data is available. Several agro-meteorological indexes have been tested in the past that range from simple rainfall indexes (Odening *et al.*, 2007; Breustedt *et al.*, 2008) to very complex crop model based indexes (Deng *et al.*, 2008; Bobojonov and Sommer, 2011). We considered a rainfall deficit index but with some modifications to improve the joint dependency of index and yield. A simple rainfall index was presented by Odening *et al.* (2007) as:

$$I^{RD} = \sum_{\tau=1}^{n} min\left(0, \sum_{t=(\tau-1)+s+1}^{\tau+s} R_t - R^{min}\right) \quad (6)$$

Usually, the value of R^{min} is set to maximize the correlation between index value and observed yields. However, we introduced some modification to the index to account for inter-seasonal and inter-annual variations for water demand in semiarid environments. We use weekly crop Evapotranspiration ($ET_{c\tau}$) instead of R^{min}. The above equation then reads as:

$$I^{RD} = \sum_{\tau=1}^{n} min\left(0, \sum_{t=(\tau-1)+s+1}^{\tau+s} R_t - ET_{c\tau}\right) \quad (7)$$

The rainfall deficit index is estimated for whole vegetation period (November-June months) where ($ET_{c\tau}$) is estimated using the CropSyst crop simulation model (Stockle *et al.*, 2003). The rainfall deficit index was then estimated from the station data and correlated with the case study farm yields.

With regard to the remote sensing based insurance index, we relied on the Normalized Difference Vegetation Index (NDVI). The NDVI is a measure of greenness density of the vegetation. The greenness itself is related to total biomass and thus to a large extent also to grain yield. NDVI data range between 0 and 1. Low vegetation biomass yields an NDVI close to zero, and high biomass close to one. NDVI has been used to estimate grain yields (Rasmussen, 1997), and, for instance, recently in the case of livestock-insurances (World Bank, 2005; Chantarat *et al.*, 2013). However, thus far limited empirical literature analyses the application for crop production related insurances. MODIS NDVI based index could be constructed for regional or farm levels at the absence of weather and yield data (Bobojonov and Sommer, 2011).

For the years 2001-2010, 250 meter spatial and 16 days temporal resolution MODIS NDVI data were obtained. Only March, April and May data were considered in the analysis since these are the critical crop growth periods of rainfed winter crops in Syria. We tested the suitability of an NDVI-based insurance to minimize volatility of revenue on farm level based on the yield data obtained from the ICARDA research farm, hereafter used as the case study farm (Figure 5).

<location of Figure 5>

FIGURE 5 250 meter resolution MODIS NDVI data for the case study farm for April 2006

Cumulative value from 127 grids (index *l*) covering the case study farm during March, April and month (index *k*) were used as the insurance index (I^{NDVI}):

$$I^{NDVI} = \sum_{l}^{127} \sum_{k}^{m} NDVI_{lk} \quad (8)$$

5. Results and discussion

5.1. Statistical approach

Estimated parameters of the Equation 5 are given in Table 1. Insurance payoff, fair premium and expected revenue with index insurance option were calculated according to the equations 1, 3 and 4 presented above.

TABLE 1 Estimated parameters of quadratic production function for wheat in Aleppo region, Zone 2

< location of Table 1>

The mean revenue estimated from 23 years of historical yield data was equal to 29,900 Syrian Pounds (SP) per hectare equivalent to 636 USD ha^{-1} yr^{-1}. The tick size was set to 31,700 Syrian Pounds (SP) and the fair premium estimated with burn analysis was equal to 6,400 SP ha^{-1}. A correlation coefficient equal to 0.72 may seem low in the estimations, and further improvement could be achieved when considering rainfall and temperature data from a network of stations instead of the single station data. Nevertheless, other studies have demonstrated that a considerable risk reduction could already be achieved if the correlation between the index and yields was higher than 0.5 (Berg and Schmitz, 2008). This potential gain can be also noted when looking at the reduction of the standard deviation of the revenue from 12,700 SP to 9,200 SP when an insurance option is considered (Table 2).

TABLE 2 Per hectare revenues in Syrian Pounds with and without insurance options

<location of Table 2>

<location of Figure 6>

FIGURE 6 Empirical cumulative distribution function with and without insurance

It can be seen from the Figure 6 that farmers purchasing an index insurance (gray line) have the opportunity of reducing the probability of having lower revenue compared to farmers who are not insured. Purchasing an insurance would guarantee a minimum revenue of 15,00 SP/ha

(Table 2). This guaranteed level of revenue would be very helpful for farmers by allowing for a budget to buy seeds and other inputs for the coming years. This type of securitization would have been very useful in 2000 and 2008 when most of the land stayed uncultivated due to lack of financial resources in response to the disastrous previous years (UN, 2008). This points to the ex-ante effects of having insurance that farmers feel their livelihood is less at risk and "feel" protected by weather insurance. As a consequence they may become more comfortable investing the right amount of money and time to optimize yield outcomes rather than minimize risk.

Certainly, purchasing an insurance contract comes at certain price which reduces the maximum revenue presented in Table 2. Consequently, revenues with insurance will be lower than revenues without insurance when climate conditions are very favourable. The additional costs associated with payments to the insurance company were equal to 21 percent of the mean revenue or 11 percent of the maximum revenue. This might seem high for Syrian farmers, and is related to the estimation of fair premium based on the burn analysis and limited number of observed years. Further investigations on index-insurance pricing with alternative pricing methods involving regional diversification might be required.

Further, the analysis of the risk coping potential of an index insurance based on district level yield data, as considered in this section, has several other shortcomings. Risk exposure at farm level may differ depending on the farm type and agro-ecological diversity (e.g. soil type) and distance to the weather station. However, previous studies demonstrated that index insurance designed with aggregated level data still leads to notable risk reduction at the farm level (Heimfarth *et al.*, 2012).

5.2. Rainfall deficit index

The mean and standard deviation of rainfall deficit index estimated according to the Equation 7 was equal to 720 and 81.8 millimetres, respectively. The minimum value of the index was 597.6 and the maximum 887.8 millimetres. The tick size was set to 350 SP and the estimated risk premium with this tick size equals 10,900 SP, which is equal to 14.6 % of the average revenue. The risk minimization potential of this index could be tested with the farm level data for the years 2000-2010. The correlation between the rainfall deficit index and yield was equal to -0.85, which indicates a good potential of this index for risk minimization. The negative sign of the correlation coefficient indicated that a larger value of the rainfall deficit reduces farm yields.

<location of Figure 7>

FIGURE 7 Revenue losses and insurance payments according to the agronomic index

The black column presents revenue shortfalls from the mean revenue for the period 2001-2010. The grey columns present insurance payments according to the agro-metrological index. It can be noticed from Figure 7 that the insurance scheme designed according to the rainfall deficit index performed very well covering revenue losses except for the year 2009.

5.3. NDVI based insurance

The mean and standard deviation of cumulative NDVI index for the months March, April and May from 127 grids was equal to 297.6 and 33.9, respectively. The correlation between the index and farm yields was equal to 0.79. This tick size was set to 850 SP which gives an insurance premium of 10,400 SP; 13.9 % of the mean revenue.

<location of Figure 8>

FIGURE 8 Revenues losses and insurance payments according to NDVI

Similarly to rainfall deficit index, NDVI based index showed very good potential to provide insurance against observed yield losses (Figure 8). However, both, the rainfall deficit index and the NDVI based index, did not trigger payments in 2009. Other factors, such as late frost or hail storms (destroying crop leaves) might have occurred in the case study farm in the year 2009, since rainfall was favourable and the NDVI also revealed good biomass in the fields. An index-based insurance does not capture such risks as well as idiosyncratic risks i.e. damage caused by farmers themselves (Miranda and Farrin, 2012). Risk associated with harvest delays, broken machinery or failure in management decisions is not covered by index insurance products. Therefore, index-based insurance cannot be considered as solution for all problems but rather an inexpensive tool to hedge weather related risk only.

The results provide evidence that all three indexes could contribute to risk minimization at regional as well as at farm level. Selection of one or another index will depend on the experience of the insurance provider and also the perception of the farmers about these products, which shapes their wiliness to pay for such a product (Patt *et al.*, 2010).

5.4. Systemic risk in Syria

The price of the index insurance product could be reduced when risk diversification options are available. The correlation of the yields in different regions of Syria was analysed in order to see the feasibility of pooling systemic risk in different regions by private or state insurance companies. In the analyses, only regions situated in Zone 1 and 2 were considered as these regions produce more than 95% of the wheat in Syria.

The yield correlation between the regions located far from each other is very low and even negative in some exceptional cases (see Appendix). For example, the yield correlation between Al-Hassakeh regions (for both Zone 1 and 2) located in the North-East and Dara regions (Zone 1 and 2) located in South-East is lower than 0.3. This is also the case for many other regions located far from each other. In contrast correlation of yields between the region such as Homs regions (Zone 1 and 2) and Hama regions (Zone 1 and 2), located very close to each other, is higher than 0.56. The correlation is low when the agricultural districts are located in different agro-ecological zones, such as Al-Ghab Zone 1 and Al-Sweida Zone 2 where yields do not correlate at all. These results differ from findings elsewhere (e.g. Germany) where stochastic dependency between the regions are usually high (Xu *et al.*, 2010). The low correlation found in our study could also be due to agronomic reasons and diversity of climate and soil conditions and heterogeneous farming systems in Syria (see Figure 1 and 2).

Low correlation of yields between some regions and low yields in both regions from time to time indicates that the yield failures in these regions are almost independent from each other. This presents a good opportunity for insurance companies cover the indemnity claims in one region through the collection of premiums in another region during the same period of time. Therefore, different agro-ecological zones and soil conditions in Syria could be one of the positive factors can make insurance prices more affordable. The risk pooling possibility explored with correlations, could be further improved with the usage of more powerful tools such as copula methods (Vedenov, 2008; Xu et al., 2010).

6. Opportunities for establishing an insurance market in Syria

The absence of agricultural insurance companies in Syria could be one of the main challenges of introducing index-based insurance. Farmers and households might be unaware of the usefulness of the index-insurance products to cope with climate risks. However, there are several aspects which may facilitate the introduction and implementation of insurance programs in Syria. First, the Syrian government has been supporting drought affected farmers through different aid programs. The Syrian Agricultural Cooperative Bank has provided interest free credits during the agricultural seasons 1999/2000 and 2001/2002 due to serious drought problems (NAPC, 2006). The state has also distributed seed and food aid to drought affected rural families (UN, 2008). Availability of state funds for drought management and existence of such service providers initiated by the state already gives a sign about the possibility of materializing the recommendations of this paper on establishing index insurance market in Syria. Furthermore, the government funds for *ad hoc* disaster payments could be more efficiently utilized when spent on establishing insurance markets (Hazell and Hess, 2010). Another endorsing environment for the fast dissemination of insurance market is the existence of several microfinance agencies established with the help of international and public funds (CGAP, 2008). The positive attitude of rural households towards such financial schemes and a good understanding of the risk sharing mechanisms constitutes a favourable environment for acceptance of risk transfer instruments.

Identifying agents, who could sell index insurance contracts, is another challenge in the initial phases of a market establishment. Patt *et al*. (2009) showed that trust of farmers in organizations providing insurance services is one of the most important determinants of insurance demand in developing countries. Experience from developing countries shows that agricultural banks have strong motivation to take the leading role of insurance agent due to their interest in safeguarding their loans (Roberts, 2005). Ministry of Agriculture and Agrarian Reform officials recommended that the Agricultural Cooperative Bank introduce an agricultural insurance program in the interview conducted by Huff (2004). The Agricultural Cooperative Bank of Syria could take a pioneer role in establishing such markets and it already has experience with adjusting its services under conditions of systemic droughts (NAPC, 2005). Furthermore, the experience of international development and research agencies in working with farmers and building acceptance among farmers could be effectively used in insurance design and implementation process. For example, ICARDA has also become one of the well-known research and development agencies in Syria. Farmers and policy makers may have trust in such international agencies as identified in the analysis of stakeholders opinion regarding barley fertilization programs (Ahmed *et al.*, 2010).

Mobile phone providers could be considered another alternative information dissemination source to announce insurance products. IFAD and WFP (2010) showed several examples where mobile phone providers became an important source for improving the risk management capacity of farmers in many developing countries. The social enterprise *MicroEnsure* is already using mobile providers to promote life insurance and reach millions of people in Tanzania and Ghana (MicroEnsure, 2013). Similarly, mobile phone companies could play an important role in disseminating information and collecting insurance premiums in cooperation with Agricultural Cooperative Bank of Syria. However, further research in identifying the trust of people in the abovementioned companies needs to be investigated as it is conducted in Africa and South America by Patt *et al.* (2009).

The current political conflict in Syria and in the whole region creates very large constraints for establishing such services. In fact, developing an agricultural support system is urgently needed in order to mitigate the impact of the extremely volatile production observed for instance in the neighbouring Gaza Strip (Mason *et al.*, 2011). In this respect, strong support from international development organizations is required to rebuild agricultural systems in Syria and make it more productive and climate resilient when security circumstances allow for such establishments.

7. Conclusions

The study investigated the suitability of three different insurance indexes for income securitization at district as well as farm levels. The analyses show that risk associated with drought could be effectively reduced when purchasing index-based insurances. Especially, the agro-meteorological and NDVI based alternative indexes have a very good potential to be implemented under limited data conditions. These novel indexes considered for the conditions of Syria could be potentially used for other countries with similar agro-ecological environments.

The analysis of yields dependencies between different regions of Syria revealed low correlation between the regions. That may provide a unique opportunity of pooling systemic risk between different regions and providing insurance with affordable prices. Establishing insurance markets will not only help farmers reduce income risks, but also support productivity improvements. Farmers will have a guaranteed income even under drought conditions, which allows them to purchase inputs in the following growing seasons and thus reduce spillover effects of droughts. Adoption of risk management tools by farmers may significantly contribute to maintaining food security at national as well as at household levels in Syria. Existence of efficient insurance markets could help smooth consumption and attract more investment in agriculture. Therefore, an index insurance has positive effects beyond merely securing farmers' income.

Lack of insurance companies and current political uncertainty are the main challenges hindering the establishment of index insurance markets in Syria. However, there are also some positive signals that may create a favourable institutional environment for launching index insurance projects in the country. Availability of the state funds for disaster aids and the positive perceptions of rural households about the risk sharing schemes could be useful to support an insurance culture and therefore insurance uptake.

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Tables

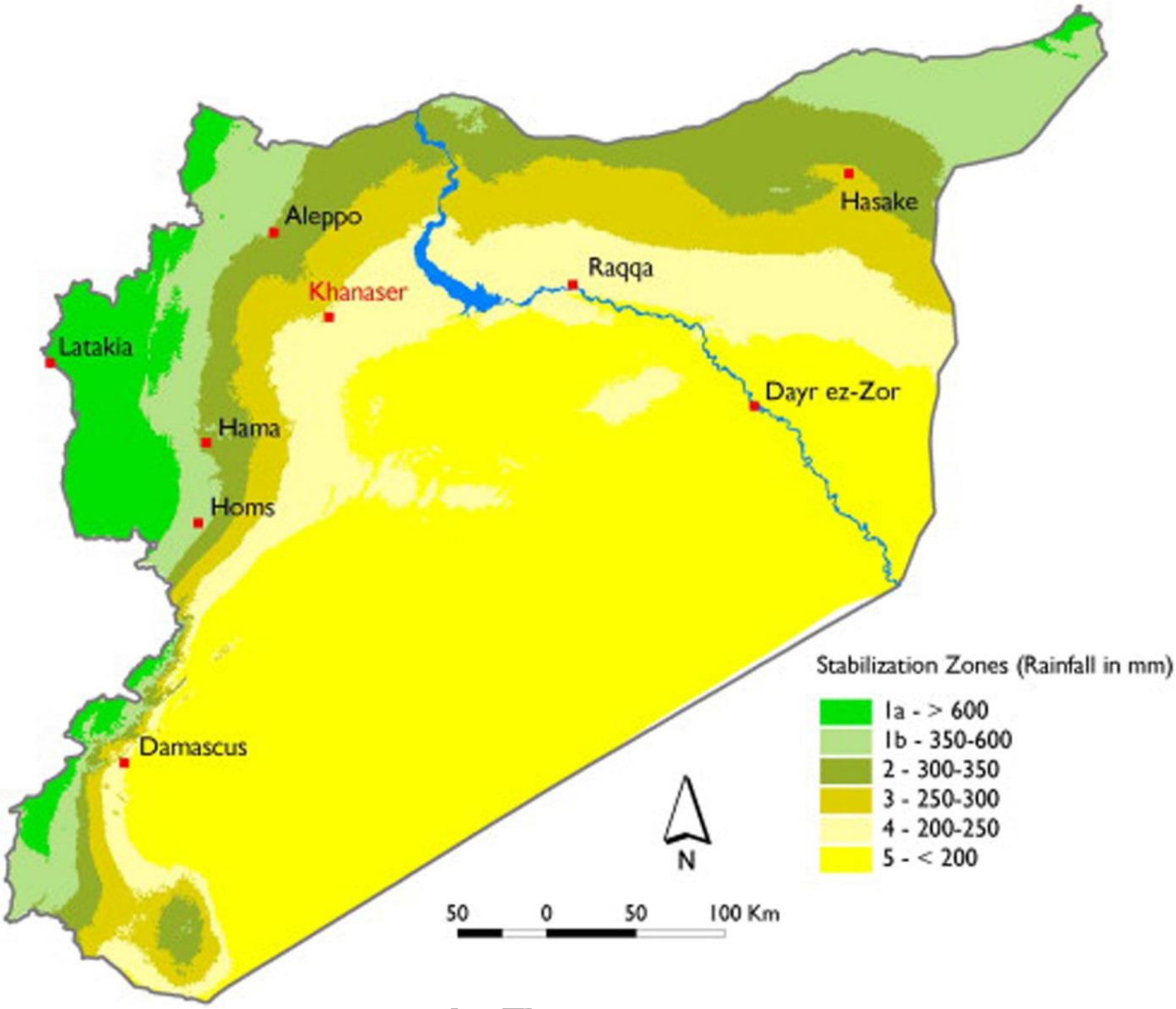
TABLE 1

	Coef.	T	$P>\lvert t\rvert$
R_{mar}	0.0061	2.41	0.030
R_{may}	0.2627	2.95	0.011
T_{may}	6.8863	2.60	0.021
R^2_{apr}	-0.0001	-2.97	0.010
R^2_{may}	-0.0006	-3.29	0.005
T^2_{apr}	-0.0043	-2.37	0.033
T^2_{may}	-0.1569	-2.53	0.024

$R_{may}T_{may}$	-0.0096	-2.50	0.026
cons	-73.7747	-2.61	0.021
R^2	0.72		
adjusted R^2	0.56		

TABLE 2

	without insurance	with insurance
mean	29891,3	29891,3
stdev	12665,6	9227,1
min	9000	15083,5
max	57000	50583,5



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551 **Figure 1**

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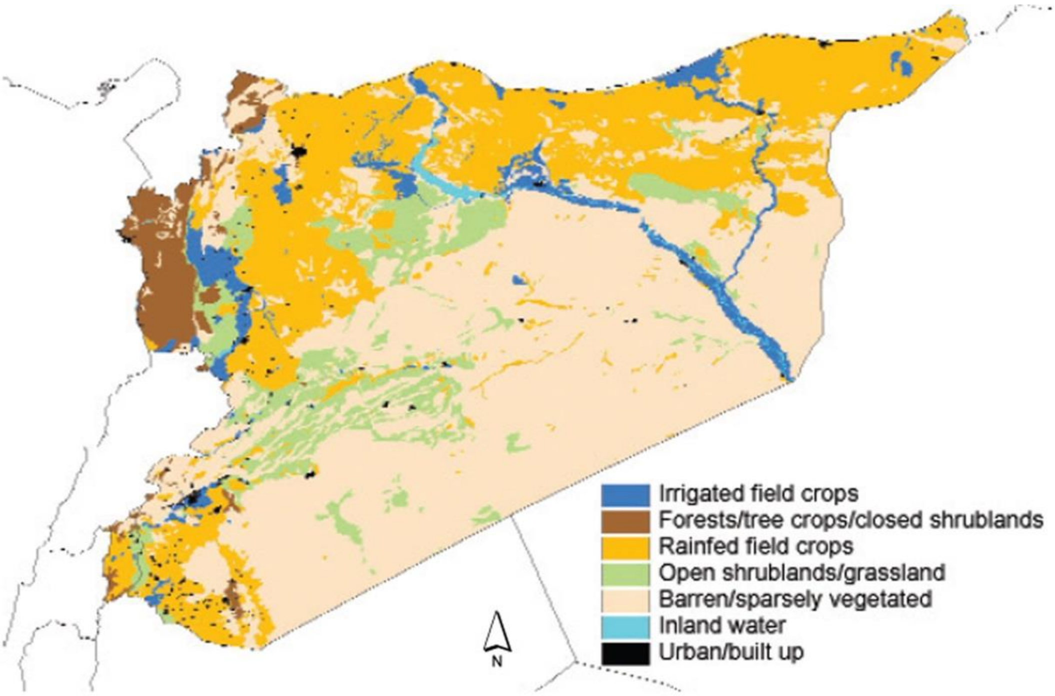


Figure 2

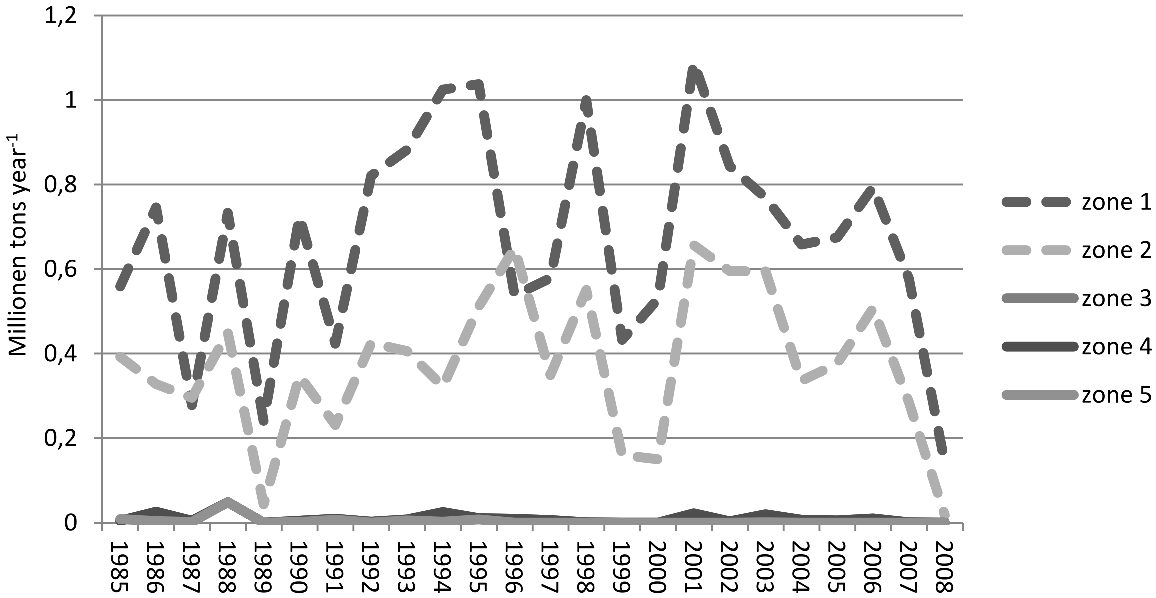
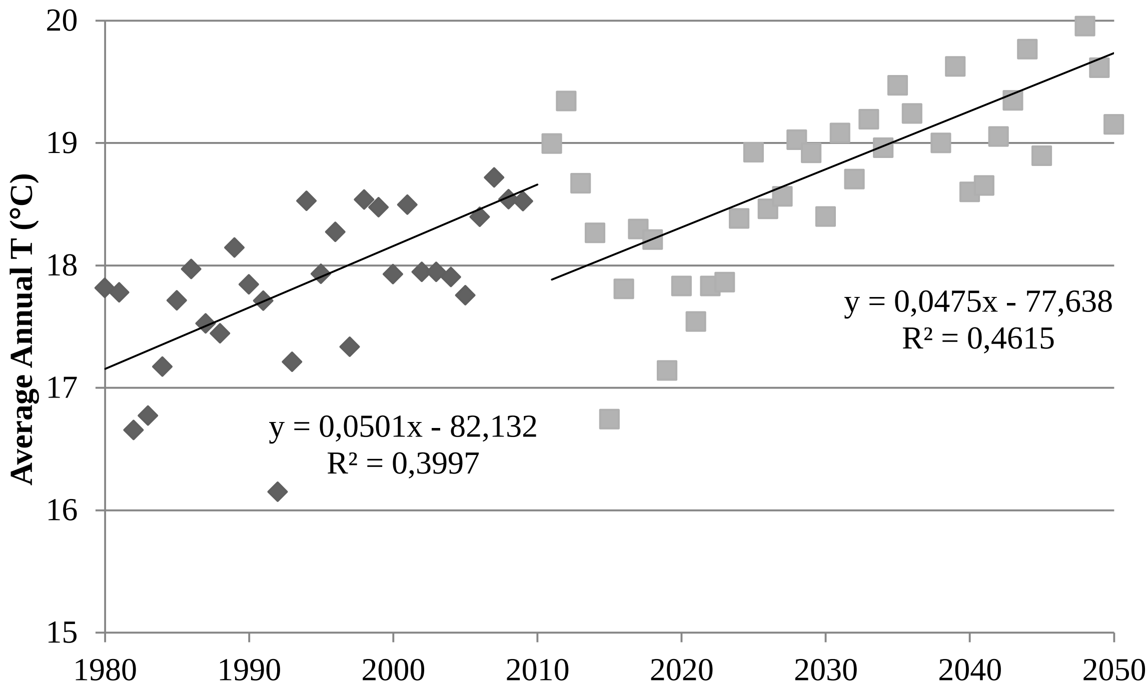


Figure 3



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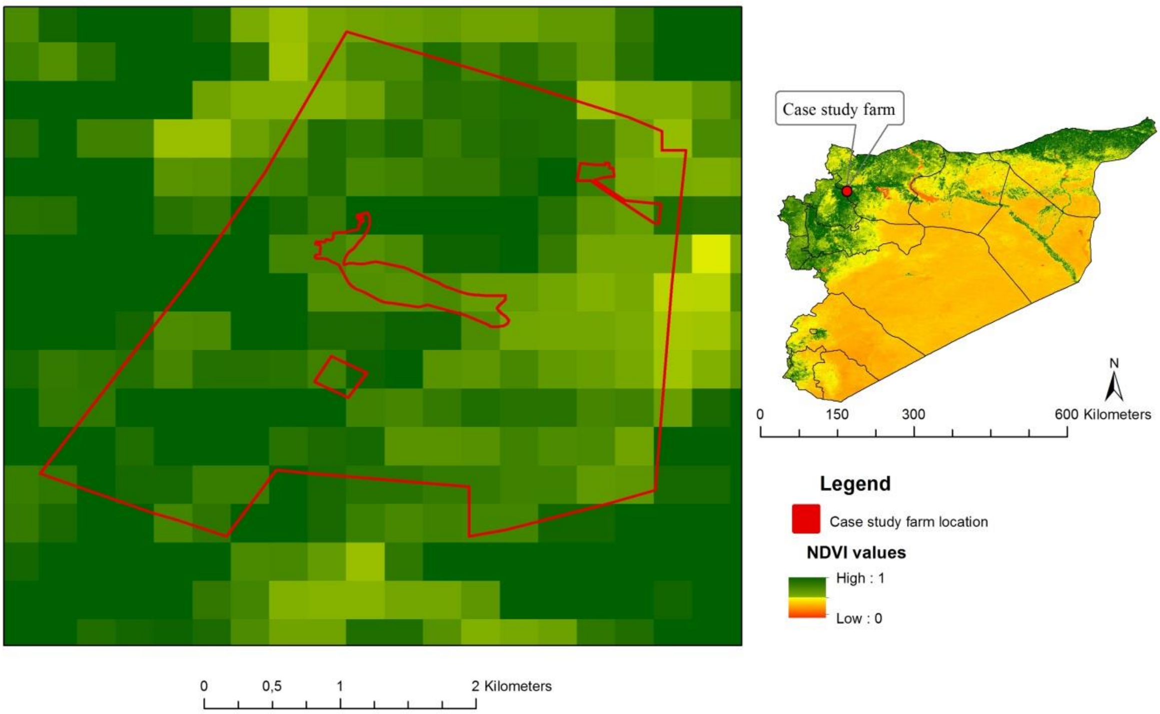


Figure 5

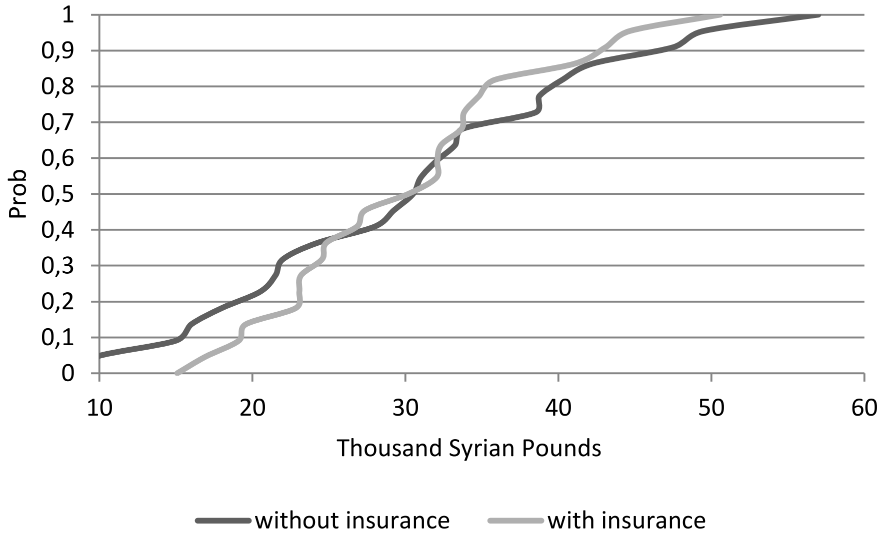
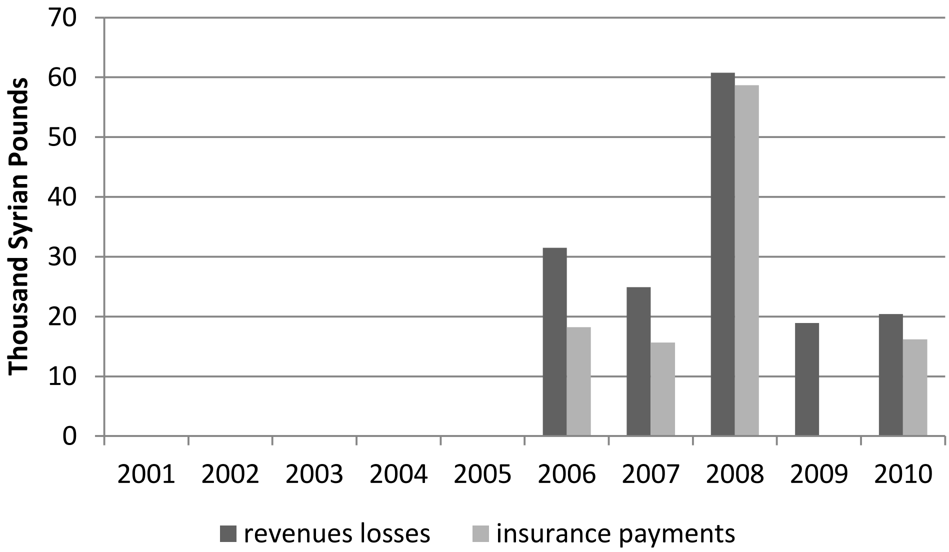


Figure 6



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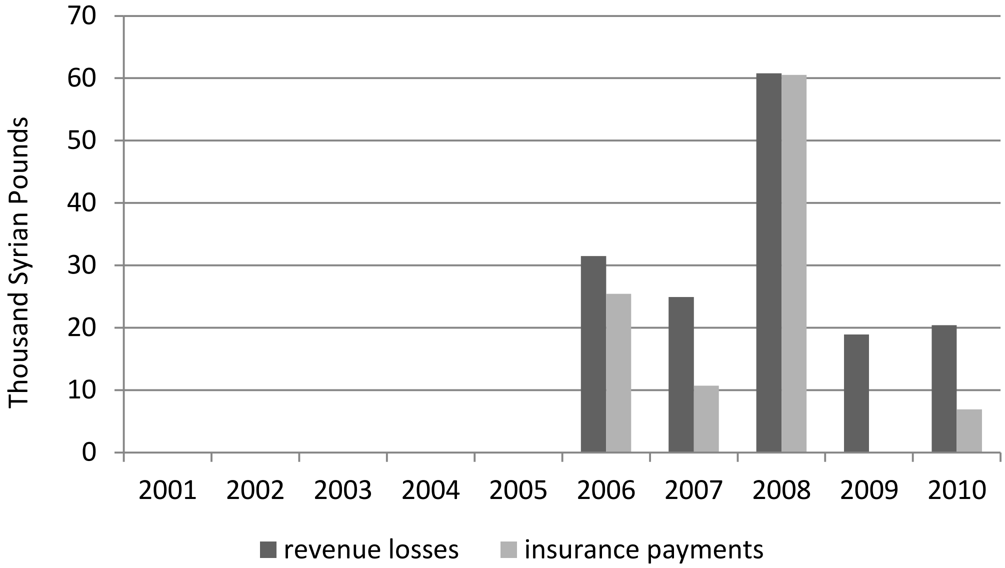

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577 **Figure 8**

APPENDIX

Correlation matrix of yields in main grain producing zones of Syria

	Al-Ghab 1	Al-Hassakeh 1	Al-Hassakeh 2	Al-Sweida 1	Al-Sweida 2	Aleppo 1	Aleppo 2	Dar'a 1	Dar'a 2	Hama 1	Hama 2	Homs 1	Homs 2	Idleb 1	Idleb 2
Al-Ghab 1	1	0,37	0,23	0,12	0,00	0,58	0,60	0,30	0,13	0,85	0,70	0,59	0,52	0,58	0,49
Al-Hassakeh 1		1	0,81	0,39	0,31	0,41	0,63	0,26	0,20	0,44	0,46	0,18	0,30	0,28	0,32
Al-Hassakeh 2			1	0,34	0,25	0,34	0,63	0,30	0,24	0,45	0,57	0,29	0,42	0,31	0,36
Al-Sweida 1				1	0,90	0,21	0,34	0,69	0,76	0,23	0,23	0,23	0,32	0,03	0,04
Al-Sweida 2					1	0,20	0,33	0,56	0,66	0,17	0,14	0,17	0,25	-0,07	-0,06
Aleppo 1						1	0,82	0,58	0,20	0,62	0,62	0,69	0,49	0,77	0,59
Aleppo 2							1	0,52	0,21	0,78	0,69	0,57	0,47	0,64	0,52
Dar'a 1								1	0,70	0,29	0,24	0,52	0,36	0,34	0,23
Dar'a 2									1	0,15	0,10	0,22	0,25	-0,01	0,02
Hama 1										1	0,87	0,56	0,61	0,66	0,62
Hama 2											1	0,62	0,73	0,65	0,67
Homs 1												1	0,81	0,53	0,29
Homs 2													1	0,45	0,38
Idleb 1														1	0,81
Idleb 2															1