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SEF WORKING PAPER 12/2017

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Working Paper 12/2017

ISSN 2230-259X (Print)

ISSN 2230-2603 (Online)

The Cost of Being Under the Weather: Droughts, Floods, and Health Care Costs in Sri Lanka

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June 2017

ABSTRACT: We measure the cost of extreme weather events (droughts and floods) on health care in Sri Lanka. We find that frequently occurring local floods and droughts impose a significant risk to health when individuals are exposed directly to these hazards, and when their communities are exposed, even if they themselves are unaffected. Those impacts, and especially the indirect spillover effects to households that are not directly affected, are associated with the land-use in the affected regions and with access to sanitation and hygiene. Finally, both direct and indirect risks associated with flood and drought on health have an economic cost; our estimates suggest Sri Lanka spends 52.8 million USD per year directly on the health care costs associated with floods and droughts, divided almost equally between the public and household sectors, and 22% vs. 78% between floods and droughts, respectively. In Sri Lanka, both the frequency and the intensity of droughts and floods are likely to increase because of climatic change. Consequently, the health burden associated with these events is only likely to increase, demanding precious resources that are required elsewhere.

JEL: I15, Q54

Keywords: Sri Lanka, flood, drought, health impact

1. Introduction

Extreme weather events (disasters) can potentially lead to significant and adverse health outcomes. There are myriad ways in which disasters can lead to deterioration of health, and to the economic challenges associated with this deterioration. In many places, climate change is predicted to increase both the frequency and intensity of extreme events such as heat waves, drought, and floods; so the costs of the health burden associated with such events could therefore increase. This health risk will grow if global warming continues unabeted, the economic burden of climate induced health goes unchecked, and investment in avoiding these costs is not made. Maybe surprisingly, there is a paucity of quantitative evidence about the extent of the current economic burden of health risk associated with extreme weather events (Smith et al., 2014; UNISDR, 2011). This lack of research interest also has the flow-on effect in that we are relatively uninformed about the future cost burden that we should expect should climate predictions materialise and become true. We thus potentially underestimate the benefits of mitigation.

Extreme weather events cause deaths and injuries, and increase health risks ranging from mental disorders to communicable diseases (Cook et al., 2008; Philipsborn et al., 2016). Increasing intensity of rainfall and subsequent floods likely elevate the risk of water-borne and vector-borne diseases; while extreme heat can cause deaths due to heat stress and increase the incidence of cardiovascular and respiratory diseases. Droughts decrease production of food, and in poor regions may result in malnutrition and its associated health risks. Floods and droughts can also cause health spill-overs into unaffected populations in disaster-affected regions since the health consequences occur through complex interactions. These interactions include the impaired ability of the health system to reduce these risks and the adverse economic consequences that are borne by indirectly affected households through reduced potential income and the strain on the provision of public services (Smith et al., 2014; Nomura et al., 2016).

Health consequence can vary with individual characteristics (age, education, income, and occupation), and the community-wide socioeconomic and political context (the health care system, national and international involvement, public security concerns, and public health policy). Land use and ecosystem change, urbanization, trade, and travel are other drivers that affect the spread of diseases (Sutherst, 2004). Ecological change arising from land use change can increase the risk of infectious diseases (McFarlane *et al*., 2013; Eisenberg *et al*., 2007). Higher population densities with inadequate urban infrastructure, changes in vegetation and ground cover, deforestation, and man-made water storage facilities can all determine the link between adverse events and disease spread (Sutherst, 2004; Cheong, Leitao and Lakes, 2016; Kweka, Kimaro and Munga, 2016, Berazneva and Byker, 2017).

Our analysis uses a cross section of households from the national Sri Lankan household income and expenditure survey of almost 80,000 individuals conducted in 2012-2013. We match this household survey data together with disaster, meteorological and land use data across the 25 administrative districts in the country to assist us in identifying the links in question: We aim to quantify the financial cost of the increased healthcare burden associated with extreme weather events.

The next section discusses the relevant literature, section 3 describes the Sri Lankan context, and section 4 focuses on the methodology and the data used in this study. Section 5 describes the results and their robustness, respectively, and section 6 concludes with some relevant policy implications for Sri Lanka and elsewhere.

2. Related Literature: The Health Impact of Disasters

Nomura *et al.* (2016) found 28 peer-reviewed observational studies on mid- and long-term health impacts of major disasters in the post-acute period (three months or more after the event). These address seven health outcomes: mortality (4), suicide (1), mental and behavioural disorders (17), diseases of the circulatory system (4), infectious and parasitic diseases (2), nutritional diseases (1) and biometric measures such as blood pressure (4). In their meta-study, these health impacts are influenced by thirty five factors related to the socioeconomic and political context, personal characteristics, and intermediating factors (e.g., behavioural responses, health system functioning, sanitation, food supply, and psycho-social circumstances). In Appendix A, we describe in detail the main diseases relating to both inpatient and outpatient treatments in Sri Lanka, and the related epidemiological literature that examined the determinants of disease outbreaks.

Ultimately, we are interested in the economic burden that disasters impose via the increasing incidence of diseases and the increasing need to provide both inpatient and outpatient health services. In Sri Lanka, health is generally a non-market sector, so that market prices rarely exist, and deriving cost is not straightforward. Studies in health economics, however, attempt to understand the total welfare cost of health care in terms of three components: the resource costs (the costs and health and non-health goods and services used in medical treatments); the lost productivity due to illness; and the disutility that accompanies many inflictions (the experienced pain and inconvenience).

When deriving the health costs of infectious diseases, a number of studies focusing on Malaria found substantial increase in household and public sector expenditure for prevention and treatment. For example, a couple of studies identified a decrease in labour inputs and low school attendance due to Malaria (Chima, Goodman and Mills, 2003; Malancy, Spielman and Sachs, 2004). Bleakley (2010) observed higher earnings among people who were born just after the eradication of malaria in United States enabling a calculation of the previous cost associated with malaria there. Using the estimated costs of the disease, and assuming these as a benefit should the disease be prevented, others calculate the benefit cost ratios for malarial prevention interventions (e.g., Mills and Shillcutt, 2004).

Another strand of this literature examined pandemics. For example, Smith *et al.* (2009) modelled the economic impact of influenza in the UK, while another study examined the impact on income associated with an outbreak of SARS (Keogh-Brown and Smith, 2008). Research in poorer countries identified, for example, the direct cost of illness due to water-borne diseases in Pakistan or the overall economic burden of water-borne diseases in Kiribati in the South Pacific (Malik, et al. 2012; and ADB, 2014, respectively).

There is, however, only a limited amount of work evaluating the health cost burden associated specifically with extreme natural hazard events such as floods and droughts (Merson, Black and Mills, 2006; IPCC, 2014; Dell, Jones and Olken, 2014). Among the available literature, there are three types of studies: on health impact, on adaptation costs and health economic evaluation studies. This last strand uses different monetary valuation methods such as the value of statistical life, disability-adjusted life years, treatment cost estimations, household health expenditure measures, and preventive health provision cost estimates.

For example, when isolating the health impact of a one degree (Celsius) increase in global annual temperature, Bosello *et al.* (2006) estimate the costs for attributed cases using a multi-country general-equilibrium model. The mortality due to vector-borne diseases (such as malaria, dengue, and schistosomiasis) is calculated first using temperature, diseases and associated mortality risks as parametrised in previous studies and then calculating the associated health costs in terms of death avoidance using treatment costs as reported by WHO. These provide inputs into their general-equilibrium model. Kovats, Lloyd, and Watkiss (2011) also use a modelling approach to estimate the marginal effect of climate change in 27 European Union countries by: quantifying the value of lives lost due to heat mortality, additional cases of salmonella and fatalities due to coastal flood.

The estimates that are produced from these models inevitably depend on the many assumptions associated with the construction of these models. Statistical quantification of observed data provides a different approach that is less structural and assumption-dependent. Knowlton, Rotkin-Ellman, Max and Solomon (2011), for example, attempt to calculate the cost of health impacts associated with events that can be related to climate change - ozone air pollution, heat waves, hurricanes, outbreak of infectious diseases, river flooding and wildfires - over a decade in United States. Mortality and morbidity from such events are measured using epidemiological studies, aggregate public health data and extrapolations when required. These are then matched with statistical estimates of the value of life, medical care costs, and lost productivity.

In low- and middle-income countries, micro-empirical approaches are more common, and probably more accurate. Lohmann & Lechtenfeld (2015), for example, empirically estimate the household level impact of drought on health expenditure in Vietnam by first estimating an illness and drought shock model, aggregating drought associates illnesses at the household level and then regressing household health expenditure on the instrumented illness measure. This study identified a 9-17% health expenditure burden on households that is due to drought-related health shocks. Our study uses a similar micro econometric approach to reveal more insights into the health economic impact of flood and drought at the spatial individual household level.

Another segment of the literature estimates the costs of adaptations to climate change related health impacts: preventing treatment cost of diarrhea cases for Europe and Central

Asia (WHO, 2013), total net cost saving in disease treatment (Agrawal, Bosello, Carraro, and De Cian, 2009) and preventing risk of malaria and diarrhoeal diseases using preventive service cost in Europe (Ebi, 2008). Evaluation of cardiovascular respiratory diseases treatment due to air pollution (Hutton, 2008), and water borne diseases vaccination programs (Goossens *et al*., 2008; Melliez *et al*., 2008).

3. Background on Natural Hazards and Health in Sri Lanka

Sri Lanka has a land area of 65,610km^2 and a coastline of approximately 1,600km. Rainfall is largely associated with tropical monsoons, but rain also occurs in other seasons. The mean annual rainfall varies from under 900mm in the driest parts (South-Eastern and North-Western) to over 5000mm in the wettest parts (Western slopes of the Central Highlands). The mean annual temperature of the lowlands varies between 26.5 °C to 28.5 °C. In the highlands, the temperature can fall to 15.9^{o}C (Department of Meteorology, 2015).[1] The country has an irregular topography comprising a broad coastal plain and a central mountainous area rising to elevations of 2,500m. This topography and differences in regional climates are underlying causes of the variation in agro-ecological zones that are identified depending on variation in rainfall and its seasonal distribution, soil, and altitude. 33% of the land is covered with forest, 43% is used for agriculture (permanent and temporary crops) , 4.4 % is of surface water bodies[2] (World Data Atlas, 2014).

Sri Lanka is affected by numerous disasters. The most frequent weather-related disasters are floods, cyclones, and droughts. For 1974-2008, the Sri Lankan government reported 1397 flood events, 1,263 events of cyclones, strong winds, surges, and gales and 285 drought events (Disaster Management Centre, 2010).[3] The seasonal distribution of floods shows two

[1] The island is divided into three climatic zones, based on the annual rainfall: Dry Zone, Wet Zone, and Intermediate Zone. The location of the south-central highlands causes interception of monsoonal rains from the southwest, and creates a 'rain shadow' on the other side. This has given rise to an ever-wet region which receives abundant rainfall from two monsoons and a Dry Zone that receives rainfall from only the north-east monsoon. The north-east dry zone is characterized by long spells of drought during other months.

[2] Sri Lanka has many major river basins, as well as a large number of man-made reservoirs.

[3] By far the worst disaster experienced in Sri Lanka since its independence was the Boxing Day Tsunami in 2004 (following an earthquake in Indonesia). Details about this event are available from numerous sources. De Alwis and Noy (2016) document the tsunami's long-term impact on Sri Lankan households.

peaks: one from April to June and the other from October to December, representing the two monsoon seasons.

As per World Bank classification, Sri Lanka is a lower middle income country, with per capita income US$ 11,500 (PPP) and a population of 20.9 million (World Bank, 2015). Sri Lanka has made considerable progress on immunization against infectious diseases; still, the most prevalent infectious diseases in recent years include vector borne ones such as dengue, and leptospirosis, and diseases transmitted orally through contamination of food or water, such as diarrhoea (dysentery), hepatitis, and typhoid fever (Ministry of Health , 2012a , 2012b). 18% of the population suffers from chronic diseases and 15% from acute diseases (UN, 2014; Department of Census and Statistics, 2014).

The government reported more than 64,000 cases of Dengue, a mosquito born viral disease, in 2012-13, with 270 reported deaths. Leptospirosis is the second high-prevalence disease as reported. Caused by bacteria and transmitted mainly by rodents it caused almost 7000 cases and almost 100 deaths in the same time period (Ministry of health, 2012a and 2013). Outbreaks of both of these are reported more during the high-rainfall months and recently, 33673 dengue cases reported during the first five months in 2017 (Sri Lanka Dengue Control Unit). Mums, Measles, and Chicken Pox are the other most common infectious diseases. The national communicable disease surveillance undertaken in 2012 also reported 80,660 outpatient visits for influenza-like illnesses and 2580 inpatients for severe respiratory tract infections (Ministry of health, 2012b). In Sri Lanka, for the last few years, influenza has been generally observed during April to June and again in November to January.[4]

Health care in Sri Lanka is mainly provided by the public sector. Total health expenditure accounts for 3.3% of total GDP. According to the world bank data (2015), It is comparable to the health expenditure of countries such as Bangladesh and the Philippines that are in the same income category, and upper-middle income countries such as Fiji and Thailand.

The government health sector is predominantly financed from general revenue taxation, while private sector financing is from out-of-pocket spending, private insurance, enterprise direct payments, insurance paid for by enterprises, and contributions from non-profit

[4] Sri Lanka faced an outbreak of influenza (mainly due to the H1N1 virus) in 2015, causing 74 deaths (WHO, 2015).

organizations. Public sector healthcare is universally accessible to the entire population and is almost wholly free of charge. Annual per capita total expenditure (from all sources) is Rs. 13,666 for which the government contribution is Rs. 8037 (Institute of Health policy, 2015). As per the national health accounts in 2013, the largest share is attributed to the treatment of non-communicable diseases (35%) followed by infectious and parasitic diseases (22%). Reproductive health services accounted for nearly 10% of health expenditures, while injuries require 7.7%. Classified by the way it is delivered and based on government health sector data, inpatient care accounts for 37.1 % of total health expenditure by the public sector and outpatient treatment with medical products (e.g., medicines) is 46.5%. Inpatient care is mainly provided by the government sector (Institute of Health policy, 2015).

In this context, this study attempts to: (1) Quantify the individual health risk attributable to flood and droughts. (2) Quantify health spillovers from flood and drought affected populations to those not directly affected and identify the associated trigger factors. (3) Identify the costs associated with the health-related disaster impacts identified in (1) and (2) for both the private and public health sectors.

4. Data and Methodology

Our data come from the National Household Income and Expenditure survey conducted between June 2012 and July 2013. The data include information on whether each household member received inpatient hospital treatment in the past year and visited a hospital (private or public) for outpatient treatment in the previous month. The survey questionnaire also posed a question on whether the households were affected in the past year by flood or drought. We combine this data with flood and drought information compiled in a separate national database to identify our treatment variables for each district – i.e., whether districts were affected by flood and drought in the past year or in the month before the HIES survey was undertaken in the 25 administrative districts across the country. District level land use data come from the district profiles maintained by the Sri Lanka Census and Statistics Department. We also use district land use data to identify how land-use affects flood and drought induced health impacts.

The summary statistics for our sample (Table 1) show that 28% of household members sought outpatient treatment in the previous month and 9% sought inpatient treatment in the previous year.[5] 4% reported themselves as affected by flood and 3% by drought in the past year. 11% reside in the districts affected by flood and 14% by drought in the month before the survey was conducted.

We estimate individual health (inpatient and outpatient) impacts using probit model specification. Our outcome variable is a binomial response for inpatient or outpatient visit for treatment. The empirical model specification is:

$$Y_{id} = \beta_2 Z_{id} + \beta_3 D_{id} + \beta_4 DSpill_{id} + \beta_5 X_d + \gamma_d + U_{id} \quad (1)$$

In the benchmark model, Y_{id} is the dependent variable – a dummy variable for hospital inpatient or outpatient treatment; the unit observed is for household *i,* in district d. D_{id} is the flood/drought (a 'treatment' binary indicator) variable, demographic and household covariates. Z_{id} are incorporated to control for heterogeneity of health outcomes due to structural factors. To control for district heterogeneity, district fixed effects are incorporated (γ) in some of the reported specifications (when the district-level land-use measures are not included). The coefficient of interest is β_3, denotes the marginal effect of flood and drought on the probability of needing inpatient or outpatient treatment. U_{id} controls for unobserved variation, and is assumed iid with mean zero.

As the health impacts associated with disasters are hypothesized to be mediated through other characteristics (vulnerabilities such as limited household sanitation), these can also affect households that are not directly impacted. These spillovers may lead to impaired health outcomes for people who are not directly affected by the flood/drought but live in the vicinity of directly affected households. To identify the health spillovers, we estimate the model including a variable ($DSpill_{id}$) that defines a separate treatment group for those people who live in flood/drought affected districts but did not self-report as being affected by flood/drought in the survey questionnaire. β_4 is the coefficient of interest to quantity the

[5] Inpatient care generally refers to any medical service that requires admission into a hospital, and is typical for more serious ailments and trauma. Outpatient care, on the other hand, is any medical service that does not require a prolonged stay at a facility. This can include routine services such as check-ups or visits to clinics (even more involved procedures such as surgical procedures, so long as they allow the patient to leave the hospital or facility on the same day).

indirect health spillovers associated with these natural hazards. To identify how land-use factors may induce disaster-triggered health risk, we incorporated these into the estimation as well; in these specifications, the district fixed effects are replaced with these district-level measures (X_d).

$$Y_{id} = \beta_2 Z_{id} + \beta_3 D_{id} + \beta_4 DSpill_{id} + \beta_5 X_d + \beta_6 Z_{id} X_d * D_{id} + \beta_7 Z_{id} X_d * DSpill_{id} + U_{id} \quad (2)$$

To identify how the external household-specific and district-level factors may induce disaster-triggered health risk, we incorporated these into the estimation in several interaction terms. In these specifications (equation 2), interaction terms of the disaster measure and the district-level factors is also introduced to the model ($Z_{id} X_d * D_{id}$) to examine the causal connection between these variables and disaster exposure and with the disaster spillover indicator ($Z_{id} X_d * DSpill_{id}$). β_6 and β_7 are the coefficients of interest that identify the answer to our question (2).[6]

In order to estimate the private cost of health impacts due to natural hazards we use the household health expenditure data collected in the survey. The monthly household health expenditure for a member experiencing inpatient treatment (at least once in last year) and receiving outpatient treatment (in the past month) is derived from estimating the household health expenditure model below (3). Y_{hd} is the household health expenditure and I_{ihd} is the inpatients/outpatients *i* in family *h* and district *d.* γ_d is the district dummies to control for district heterogeneity in health costs.

$$Y_{hd} = \beta_1 + \beta_2 X_{ihd} + \beta_3 I_{ihd} + \gamma_d + U_{id} \quad (3)$$

Finally, the total public costs of health due to flood and drought are calculated using the average per capita public health expenditure for inpatient and outpatient treatment in each district reported in the national health accounts of Sri Lanka (Institute for Health Policy, 2015).

In the last step, the average number of inpatients and outpatients due to drought and flood at the district level is calculated using the marginal effect estimated in our models, and the district average number of inpatients and outpatients associated with extreme weather

[6] We also estimated a more restricted model: $Y_{id} = \beta_1 + \beta_2 Z_{id} + \beta_3 D_{id} + \gamma_d + U_{id}$ that does not include the hypothesized spillover effects (directly unaffected households that reside in affected districts). Results for these regressions are available from the online appendix:
https://sites.google.com/site/noyeconomics/research/natural-disasters.

events is used in conjunction with the per capita health expenditure costs described above to calculate the overall cost for each Sri Lankan district.

5. Results

We estimate our models (1) and (2) separately for floods and droughts, and for inpatient and outpatient care. Table 2 provides the inpatient-flood results, table 3 the inpatient-drought, while tables 4-5 do the same for outpatient services (flood and drought). These results are discussed separately in each of the sections below.

5.1. Health impacts of floods: Inpatient care

Estimates of the parameters for equation (1) are provided in columns (i), (ii), and (iv) of table 2, while estimates of equation (2) are provided in columns (iii) and (v) for the interaction with household-specific measures, and columns (vi)-(viii) for the full model, including the district land-use interaction terms.

Consistently through the estimations in columns (i)-(v), we observe that the likelihood of receiving inpatient hospital treatments increases by about 15% for households experiencing flooding. The spillover risk, the risk of inpatient hospitalization for households experiencing the floods only indirectly is lower (about 10%) and less consistently estimated.

Controlling for household-level sanitation and water access indicators, as in column (ii) does not change the point estimates for the disaster variables of interest. Not surprisingly, we observe that the risk of inpatient treatment increases markedly for households that do not have an in-house toilet (and use shared or public facilities) and these that access water from a well or an “unsafe” source. The interactions between these household-level sanitation measures and the disaster risk variables does not yield much additional insight. There is some evidence that the increased risk of indirect (spillover) flooding damage leading to inpatient hospitalization is concentrated in those households that also do not have access to their own clean water source. We hypothesize that this is related to contaminations to public water sources in the aftermath of floods (contaminations that do not adversely impact households which have their own sources of drinking water), but of course we do not have evidence that this is the causal link.

These results do not change markedly when we include district-level fixed effects in columns (iv)-(v). Changes that we do observe are probably because some of the differences across households, in terms of their access to sanitation services, are most likely not randomly distributed across districts (with some districts having better or worse sanitation, on average). Once again, the only statistically observable interaction term is the one associated with spillover (indirect) flood effects and drinking water access.

To examine the role of spatial land-use factors, we estimate specifications (vi) and (vii) by replacing district fixed effects with district level land-uses: Agricultural water retention areas and larger water retention areas. Agricultural water retention areas comprise the irrigated and rain fed paddy that act as low lying water retention areas during rain. Irrigation tanks and larger reservoirs are included in larger water retention areas. Other than their main purpose (irrigation and hydro power generation), they provide water for household needs.

The model (vi) with the land use variables shows a significant reduction of spillover effects, suggesting that these may only be driven exposure to significant agricultural water retention areas (such as rice paddy fields). Once one controls for the presence of large water retention areas, the spillover coefficient is no longer statistically or materially significant; this remains the case when the water-retention control is interacted with the spillover indicator (column vii).

The direct adverse impact of flooding on inpatient treatment, however, is robust to the inclusion of the water-retention control with an estimated increased probability of 11%. Direct damage from flooding is expected to be correlated somewhat with the probability of flooding, so the estimated direct impact of flooding is reduced somewhat when the full model is estimated in columns (vii) and (viii), but the interaction terms is still positive (increased likelihood of hospitalization) and statistically significant. Much of the other results do not change materially, including our previous conclusions with respect to the importance of sanitation (toilet access) in determining the health risk burden, and the interaction between spillover effects and in access to clean drinking water as increasing risk.

5.2. Health impacts of droughts: Inpatient care

Table 3 presents droughts' impact on inpatient treatment similarly to the presentation of results for floods in the previous table. As before, our estimated model assumes drought may have both direct and spillover health effects.

The immediate and most obvious observation is that droughts exert a much stronger impact on the likelihood of hospitalization (inpatient care) than do floods. The probability that a household member will need to be hospitalized increased by up to 50% (column iv) if the household was affected by a drought. Likewise, the spillover effect also seems to be larger (for households that did not report being affected by a drought but reside in districts that are affected). But, as being impacted by a drought is less easy to define than by a flood, so interpretation of this 'spillover effect' is more challenging.

As with the previous analysis of flood risk and inpatient care, there is some evidence that sanitation is associated with more health services utilization for households that report being directly affected, and those that are defined as 'spillover' households in our framework. The land-use data, however, is less materially connected to these adverse impacts in the case of droughts, with coefficient estimates that are much smaller (and statistically significant coefficients that appear to annul each other).

5.3. Health impacts of floods and droughts: Outpatient care

The next table, table 4, analyses the effect of experiencing a flood on the use of outpatient services. In this case, the dependent variable is whether a household member used outpatient services in the previous month and the main variable of interest is whether districtwide flood occurred during that the same month. As before (for hospitalizations), we observe that households that live in a district that flooded are significantly more likely to require outpatient services (this increase is statistically significant and substantial at around 7-11%; estimated from specifications in columns (i) and (iv).

The estimated model also consistently shows that households that do not have their own private toilet facilities are at a significantly higher risk of requiring health treatment (irrespective of their weather hazard exposure). When households do not possess in-house source for drinking water, their need for outpatient health services only increases if there is a flood (the interaction coefficient is positive and significant) but does not make much difference in the absence of flooding (column iii).

These results remain when we control for land-use, and the interaction between land-use and hazard occurrence. In this case—columns (vi) and (vii)—the coefficient for the land-use and the interaction terms are sometimes statistically significant, but their real magnitude is quite small (0.01-0.03). So, it appears that in the case of outpatient services and flooding, land-use indicators (at the district level) do not exert much affect.

In table 5, we revisit the same dependent variable, outpatient services, but this time for droughts. As before, column (i)-(iv) provide the benchmark specifications that include demographic controls and also the sanitation indictors. As we observed previously for inpatient services, the probability of requiring outpatient services following a drought is statistically and materially significant, and larger than the increase associated with flooding. In this case, the estimated increase in probability is in the order of 8-15%. And similarly to the results for floods, the likelihood of needing outpatient care increases when households do not have access to their own toileting facilities and access public or shared facilities.

The evidence on the interaction between the drought hazard measure and both the sanitation and land-use indicators is not very robust. We cannot unearth robust evidence that suggests that the impact of droughts is mediated substantially through the access to sanitation or land-use measures (columns v-vii).

5.4. District-level health cost of flood and drought

Table 6 provides information about the estimation specification described in equation (3). In these, we estimate the average increase in health expenditures at the household level associated with an episode of inpatient or outpatient health service utilisation. Not very surprisingly, we note that inpatient care is on average about three times as costly, for the household, as is outpatient care. Other interesting observations that arise out of these estimates is that the expenditure associated with males and older patients are higher (on average). Households with higher socio-economic status (better educated, belonging to the Sinhalese majority, having higher income, and being urban) are all associated with more health expenditures associated with inpatient and outpatient care.

In order to assess the overall costs associated with the health services provided to the hazard-impacted population, we need to measure the population's vulnerability to flood and drought-caused utilization of health services across districts; these estimates are provided in table 7. These district level population vulnerability to adverse health due to flood and drought is calculated by multiplying the district average health risk, the district population and the point estimates of the disaster shock variable (marginal effect of flood and drought on health services utilization) as estimated in the regressions detailed above.

Table 8 shows the total cost estimate due to drought and flood, separated to the costs associated with the private and public sectors. The estimations are based on Sri Lanka population census of 2012. Public health cost are based on the reported district level per capita health expenditure; while the private costs were estimated in table 6. The estimated realization of the district level health burden is derived from the population in each district in each year and from whether districts were actually exposed to flood and drought in the same year.

6. Conclusions, Caveats, and Climate Change

This study sat out to determine the economics of the extreme weather impacts on health. The most obvious finding emerging from our analysis is that frequently occurring local floods and droughts impose a significant health risk to individuals' health when they are exposed directly to these hazards, and that this sometime requires even hospitalization for treatment. Those impacts, and especially the indirect spillover effects to households that are not directly affected by the hazard, are associated with the land use in the affected environs of the hazard, and with the household's access to sanitation and hygiene. Why sanitation and hygiene are important in mediating the impact of floods and droughts probably does not need explaining. The most likely causal story to our observations about land-use interacting with both floods and droughts is that both drought and floods lead to a higher likelihood of contaminants and infections being transmitted (most likely orally) when human-made bodies of water are prevalent in the affected area as they interact with the water available for human consumption.

The health spillovers we identified are almost always appear to be associated with the household sanitation and hygienic conditions. Flood health spillovers are associated with the households using unsafe drinking water sources (wells and other unsafe sources). It seems that flooding increases the likelihood of contamination of public water sources. Other possible epidemiological explanations for our spillover finding is the increased presence of disease transmitting vectors (e.g., mosquitos) in the aftermath of floods, an increase that affects also households that were not directly damaged by the event.

Finally, both direct and indirect risks of flood and drought on individual health has an economic cost associated with it, with a consequent welfare loss. Overall, our estimates suggest Sri Lanka spends 52.8 million USD per year on health care costs associated with floods and droughts, divided almost equally between the public and household sectors, and 22% vs. 78% between floods and droughts. Worryingly, our calculations show that the health burden is distributed spatially so that the highest per capita burden is experienced by the Uva, Northern, North Central and Eastern regions, which are situated in dry zone of Sri Lanka (Figure 2). These are also the poorer regions of the country. The Western province is the richest region in the country, that nearly has double the monthly per capita income of these provinces and it also bears the least per capita health burden associated with floods and droughts. However, the total health burden is highest among Western, North Western and Southern provinces (figure 1).

It is worth noting that the estimated health-expenditure burden quantified in this paper is only a part of the full economic cost of this health burden. The cost in this paper is estimated in terms of direct public and household expenditure on disease treatment not the full accounting of costs. Underestimation of actual costs is likely since household members presumably experience reduced productivity and reduced ability to generate income during their treatment. Equally, the opportunity cost of government spending resources on these health costs is probably also substantial, as the opportunities for more productive fiscal expenditures are more numerous in countries with low capital base and one that is rapidly developing (as is the case in Sri Lanka). Our estimated drought effect may also be underestimated since drought causes longer term effects beyond one year while our equation (3) only focuses on same year health expenditures.

Finally, regional climate model projections for future temperature project increases for Sri Lanka: 1.0°C–1.1°C by 2030, and 2.3°C–3.6°C by 2080. Accordingly, precipitation is likely to increase by 3.6%–11.0% by 2030, and 31.3%–39.6% by 2080 (Ammed and Suphachalasai, 2014). Studies also predict higher frequencies of high intensity rainfall events causing floods and low rainfall periods generating drought conditions (Ministry of Environment, 2010). In short, both the frequency and the intensity of droughts and floods are likely to increase because of climatic change, though the magnitude of these increases is as yet unknown. Consequently, the health burden of these events is only likely to increase, further demanding precious resources that are required elsewhere in a rapidly growing but still relatively poor country.

Table 1: Data Summary

Variables	Mean	Std. Dev.	Min	Max
Sex (Dummy for Male=1)	0.48	0.50	0	1
Age (years)	32.6	21.5	0	99
Education (years)	8	4.7	0	19
Ethnicity_ Singhalese (Dummy)	0.65	0.48	0	1
Ethnicity_ Tamil (Dummy)	0.34	0.47	0	1
Employed (Dummy)	0.23	0.42	0	1
Employer(Dummy)	0.01	0.80	0	1
Own family worker(Dummy)	0.12	0.33	0	1
Reside in Rural sector(Dummy)	0.65	0.48	0	1
Reside in Estate sector(Dummy)	0.10	0.29	0	1
Outpatient visit at least once last month	0.28	0.45	0	1
Inpatients visit at least once last year	0.09	0.28	0	1
Flood affected last year (Dummy for Self-Reported)	0.04	0.20	0	1
Flood affected last year (Dummy district wide flood)	0.72	0.45	0	1
Drought affected (Dummy for Self-reported)	0.03	0.17	0	1
Drought affected last year (in affected District)	0.32	0.47	0	1
Flood affected last month (in affected District)	0.11	0.31	0	1
Drought affected last month (in affected District)	0.14	0.35	0	1
Flood spill-over	30	46	0	1
Drought spill-over	68	46	0	1
Households_ Toilet shared (Dummy)	0.06	0.24	0	1
Households_ Toilet Public(Dummy)	0.04	0.19	0	1
Households_ Drinking water _Well(Dummy)	0.48	0.49	0	1
Households_ Drinking water _Open sources(Dummy)	0.18	0.38	0	1
Agricultural water retention area (% of land in district)	11.09	5.73	0	23.7
Natural water retention area (% of land in district)	4.98	3.24	0	18.6
Household income	29790	31656	-3750	324275
Household health expenditure	1544	13645	0	1103400

NOTE: There are 79,381 observations.

Table 2: Health impacts of flood: Inpatient health treatments per year due to flood

Variables	(i)		(ii)		(iii)		(iv)		(v)		(vi)		(vii)		(viii)	
Self-reported flood (Dummy)	0.15***	(0.03)	0.15***	(0.03)	0.16***	(0.03)	0.13***	(0.04)	0.15***	(0.06)	0.11***	(0.06)	-0.04	(0.09)	0.003	(0.08)
Flood spillover(Dummy)	0.11***	(0.02)	0.12***	(0.02)	0.05*	(0.02)	0.08***	(0.02)	0.01	(0.03)	0.02	(0.03)	-0.04	(0.04)		
Hygienic variables																
Shared Toilet (Dummy)			0.14***	(0.03)	0.16***	(0.03)	0.15***	(0.03)	0.17***	(0.05)	0.15***	(0.05)	0.16***	(0.05)	0.15***	(0.03)
Public Toilet (Dummy)			0.27***	(0.03)	0.22***	(0.05)	0.26***	(0.05)	0.25***	(0.08)	0.22***	(0.08)	0.24***	(0.08)	0.26***	(0.03)
Drinking Water well(Dummy)			0.10***	(0.02)	0.04***	(0.03)	0.07***	(0.03)	0.002	(0.03)	0.01	(0.03)	0.01	(0.03)	0.09***	(0.002)
Drinking water unsafe source(Dummy)			0.04***	(0.02)	-0.05	(0.04)	-0.01	(0.02)	-0.12***	(0.04)	-0.06	(0.04)	-0.07*	(0.04)	0.05***	(0.02)
Self-reported*toilet_share					-0.18	(0.12)			-0.17	(0.12)	-0.18	(0.12)	-0.14	(0.12)	-0.13	(0.11)
Self-reported *toilet_public					0.07	(0.13)			0.04	(0.13)	0.06	(0.13)	0.08	(0.13)	0.05	(0.10)
Self-reported *DrinkingWater_Well					-0.01	(0.07)			-0.01	(0.07)	0.01	(0.07)	0.02	(0.07)	-0.07	(0.0)
Self-reported *DrinkingWater_unsafe					-0.06	(0.11)			-0.09	(0.11)	-0.07	(0.11)	-0.06	(0.11)	-0.19*	(0.10)
Spillover *toilet_share					-0.01	(0.06)			-0.01	(0.06)	-0.001	(0.06)	-0.01	(0.06)		
Spillover *toilet_public					0.06	(0.09)			0.003	(0.09)	0.04	(0.09)	0.02	(0.09)		
Spillover *DrinkingWater_Well					0.09**	(0.03)			0.09***	(0.04)	0.12***	(0.04)	0.12***	(0.04)		
Spillover *DrinkingWater_unsafe					0.12***	(0.05)			0.17***	(0.05)	0.15***	(0.05)	0.16***	(0.05)		
Agricultural Water Retention area (%)											0.02***	(0.001)	0.02***	(0.004)	0.02***	(0.001)
Agric_water retention*self-reported													0.03***	(0.01)	0.03***	(0.01)
Agric_water retention*Spillover													-0.002	(0.004)		
Larger Water Retention area (%)											-0.01***	(0.002)	-0.03***	(0.01)	-0.01***	(0.002)
Larger water retention*self reported													-0.03*	(0.02)	-0.05***	(0.02)
Larger water retention* Spillover													0.02***	(0.01)		
Demographic factors	Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes	
District fixed effects	No		No		No		Yes		Yes		No		No		No	
Observations	79381		79381		79381		79381		79381		79381		79381		79381	
chi2	1169.5		1306		1321.5		1938.9		1953.3		1540.9		1566.9		1494.8	
P	0		0		0		0		0		0		0		0	
Pseudo R2	0.03		0.03		0.03		0.04		0.04		0.03		0.03		0.03	

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Health impacts of drought: inpatient health treatments per year

Variables	(i)		(ii)		(iii)		(iv)		(v)		(vi)		(vii)		(viii)	
Self-reported Drought (Dummy)	0.29***	(0.03)	0.30***	(0.03)	0.20***	(0.09)	0.50***	(0.07)	0.42***	(0.12)	0.07	(0.08)	0.11	(0.15)	0.11	(0.16)
Drought spillover(Dummy)	0.06***	(0.01)	0.07***	(0.01)	0.07***	(0.02)	0.37***	(0.09)	0.32***	(0.09)	0.01	(0.03)	-0.02	(0.04)		
Hygienic variables																
Shared Toilet (Dummy)			0.14***	(0.03)	0.09***	(0.03)	0.15***	(0.03)	0.11***	(0.03)	0.09***	(0.03)	0.10***	(0.03)	0.14***	(0.03)
Public Toilet (Dummy)			0.28***	(0.03)	0.27***	(0.04)	0.26***	(0.03)	0.24***	(0.03)	0.25***	(0.03)	0.25***	(0.04)	0.26***	(0.03)
Drinking Water well(Dummy)			0.09***	(0.03)	0.10***	(0.01)	0.07***	(0.02)	0.06***	(0.02)	0.09***	(0.02)	0.09***	(0.02)	0.07***	(0.02)
Drinking water unsafe sources(Dummy)			0.03	(0.02)	0.27***	(0.04)	0.003	(0.02)	-0.03	(0.03)	0.03	(0.03)	0.03	(0.02)	0.04**	(0.02)
Self-reported*toilet_share					0.07	(0.15)			0.10	(0.15)	0.05	(0.15)	0.07	(0.15)	0.02	(0.15)
Self-reported *toilet_public					0.01	(0.14)			0.07	(0.15)	0.03	(0.15)	-0.003	(0.15)	-0.01	(0.15)
Self-reported *DrinkingWater_Well					0.14	(0.09)			0.10	(0.10)	0.20***	(0.09)	0.17*	(0.10)	0.18*	(0.10)
Self-reported *DrinkingWater_unsafe					0.04	(0.11)			0.02	(0.12)	0.12	(0.12)	0.05	(0.11)	0.03	(0.12)
Spillover *toilet_share					0.15***	(0.05)			0.15***	(0.06)	0.15***	(0.06)	0.15***	(0.06)		
Spillover *toilet_public					0.01	(0.07)			0.04	(0.07)	0.04	(0.07)	0.04	(0.07)		
Spillover *DrinkingWater_Well					-0.03	(0.03)			0.01	(0.03)	-0.04	(0.03)	-0.04	(0.03)		
Spillover *DrinkingWater_unsafe					0.02	(0.04)			0.08**	(0.04)	0.03	(0.04)	0.03	(0.04)		
Agricultural Water Retention area (%)											0.02***	(0.001)	0.02***	(0.001)	0.02***	(0.001)
Agric_water retention*Self-reported													-0.02**	(0.005)	-0.02***	(0.01)
Agric_water retention*Spillover													-0.002	(0.01)		
Larger Water Retention area (%)											0.01	(0.14)	-0.01	(0.002)	-0.01***	(0.002)
Larger water retention*Self-reported													0.04**	(0.02)	0.04**	(0.02)
Larger water retention* Spillover													0.01*	(0.01)		
Demographic factors	yes		yes		yes		yes		yes		yes		yes		yes	
District fixed effects	No		No		No		yes		yes		No		No		No	
Observations	79381		79381		79381		79381		79381		79381		79381		79381	
chi2	1198.1		1184.6		1351.0		1971.0		1988.0		1545.2		1553.5		1534.3	
P	0		0		0		0		0		0		0		0	
Pseudo R2	0.03		0.03		0.03		0.04		0.04		0.03		0.03		0.03	

Table 4: Immediate health effects of flood : Outpatient treatments due to districtwide flood exposure

Variables	(i)		(ii)		(iii)		(iv)		(v)		(vi)		(vii)	
Flood affected last year (Dummy)	0.11***	(0.02)	0.12***	(0.02)	0.05*	(0.03)	0.07 ***	(0.02)	0.01	(0.03)	0.02	(0.03)	-0.04	0.04
Hygienic variables														
Shared Toilet (Dummy)			0.14***	(0.03)	0.15***	(0.05)	0.15***	(0.03)	0.17***	(0.05)	0.15***	(0.05)	0.16***	(0.05)
Public Toilet (Dummy)			0.27***	(0.03)	0.20**	(0.08)	0.25**	(0.03)	0.24***	(0.08)	0.21***	(0.08)	0.23**	(0.08)
Drinking Water well(Dummy)			0.10***	(0.02)	0.04	(0.03)	0.06***	(0.02)	-0001*	(0.03)	0.02***	(0.03)	0.002	(0.03)
Drinking water open source(Dummy)			0.04**	(0.02)	-0.06	(0.04)	0.01	(0.02)	-013***	(0.04)	0.01	(0.04)	-0.08**	(0.04)
Flood*toilet_share					-0.02	(0.05)			-0.02	(0.05)	-0.01	0.06	-0.02	0.05
Flood*toilet_public					0.07	(0.08)			0.02	(0.09)	0.06	(.009)	0.03	(.009)
Flood*DrinkingWater_Well					0.08**	(0.02)			0.08**	(0.03)	0.11***	(0.03)	0.12***	(0.04)
Flood*DrinkingWater_unsafe					0.12***	(0.04)			0.18***	(0.04)	0.15***	(0.05)	0.17***	(0.05)
Agricultural Water Retention area (%)											0.02***	(0.001)	0.02***	(0.001)
Agric_water retention*Flood													-0.002	0.003
Larger r Water Retention area (%)											-0.01***	(0.002)	-0.03***	(0.01)
Larger water retention*Flood													0.02***	(0.01)
Demographic factors	yes		yes		yes		yes		yes		yes		yes	
District fixed effects	No		No		No		yes		yes		No		No	
Observations	79381		79381		79381		79381		79381		79381		79381	
chi2	1168.7		1305.7		1317.5		1949.5		1943.2		1535.2		1551.38	
P	0		0		0		0		0		0		0	
Pseudo R2	0.03		0.03		0.03		0.04		0.04		0.03		0.03	

Standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Immediate health effects of drought : Outpatient treatments due to districtwide drought exposure

Variables	(i)		(ii)		(iii)		(iv)		(v)		(vi)		(vii)	
Drought affected last month	0.13^{***}	(0.01)	0.13^{***}	(0.01)	0.15^{***}	(0.02)	0.08^{***}	(0.02)	0.11^{***}	(0.03)	0.07^{**}	(0.02)	0.05	(0.05)
Hygienic variables														
Shared Toilet (Dummy)			0.07^{**}	(0.02)	0.06^{***}	(0.02)	0.08^{***}	(0.02)	0.07^{***}	(0.02)	0.07^{**}	(0.02)	0.07^{**}	(0.02)
Public Toilet (Dummy)			0.05^{*}	(0.03)	0.04	(0.03)	0.06^{**}	(0.03)	0.04	(0.03)	0.03	(0.03)	0.03	(0.03)
Drinking Water well(Dummy)			-0.02^{*}	(0.01)	-0.01	(0.01)	0.01	(0.01)	0.01	(0.01)	-0.01	(0.01)	-0.01	(0.01)
Drinking water open source(Dummy)			-0.02	(0.02)	0.01	(0.02)	-0.01	(0.02)	-0.002	(0.02)	-0.01	(0.02)	-0.01	(0.02)
Drought *toilet_share					0.05	(0.06)			0.04	(0.06)	0.04	(0.06)	0.04	(0.06)
Drought *toilet_public					0.12^{*}	(0.07)			0.11	(0.07)	0.14^{*}	(0.07)	0.14^{*}	(0.07)
Drought *DrinkingWater_Well					-0.04	(0.03)			-0.06^{**}	(0.03)	-0.05	(0.03)	-0.06^{*}	(0.03)
Drought *DrinkingWater_unsafe					-0.04	(0.04)			-0.02	(0.04)	-0.01	(0.04)	-0.02	(0.04)
Agricultural Water Retention area (%)											0.02^{***}	(0.001)	0.02^{***}	(0.001)
Agric_water retention*Drought													-0.01^{***}	0.002
Larger Water Retention area (%)											-0.03^{***}	(0.002)	-0.03^{***}	(0.002)
Larger water retention*Drought													0.05^{***}	0.01
Demographic factors	yes		yes		yes		yes		yes		yes		yes	
District fixed effects	No		No		No		yes		yes		No		No	
Observations	79381		79381		79381		79381		79381		79381		79381	
chi2	3768.9		3785.6		3791.5		4477.92		4485.49		4153.2		4203.6	
p	0		0		0		0		0		0		0	
Pseudo R2	0.4		0.04		0.04		0.04		0.05		0.05		0.05	

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Private health cost (per month) for an individual being inpatient and outpatient duting past year

Variables	(i)		(ii)		(iii)	
Inpatient (At least once last year)			**1720.18*****	(166.9)	**1602.2*****	(17643)
Outpatient (At least once last month)	**709.3*****	(111.0)			**502.4*****	(113.03)
male or female (Dummy)	180.7*	(104.1)	171.33*	(104.03)	169.90*	(103.98)
Age (Years)	10.92***	(2.55)	10.82***	(2.53)	8.471***	(2.56)
Education (Years)	64.71***	(11.42)	58.54***	(11.34)	63.16***	(11.42)
Sinhalese (Dummy)	449.64	(753.52)	469.45	(750.89)	467.38	(753.47)
Tamil (Dummy)	227.57	(753.58)	170.25	(753.20)	543.61	(760.99)
Employed(Dummy)	-486.24***	(131.59)	-509.70***	(131.13)	-458.47***	(131.57)
Employer(dummy)	-564.42	(607.37)	-553.99	(607.11)	-5484.53	(606.81)
Own family worker(dummy)	-710.62***	(163.47)	-716.05***	(163.22)	-546.22***	(164.44)
Rural sector (dummy)	-290.97**	(121.34)	-305.15***	(121.31)	-179.87***	(127.30)
Estate sector(Dummy)	-778.76***	(197.29)	-755.90***	(197.15)	-672.13***	(224,02)
Total income (Rs.)	0.02***	(0.002)	0.02***	(0.001)	0.02***	(0.001)
Time to hospital	-29.9***	(7.77)	-30.72***	(7.76)	-26.81	(8.03)
Constant	31.31	(760.31)	49.19	(758.89)	-1149.43	(890.56)
Observations	79381		79381		79381	
R^2	0.005		0.006		0.01	
F	32.85		37.32		36.26	
df_m	13		13		14	

Standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7: District level population vulnerability to flood and drought related health risk

Province	District	A(i)	%	A(ii)	%	A(iii)	%	B(i)	%	B(ii)	%	B(iii)	%
Western	Colombo	18016	0.8	11087	0.5	38805	1.7	69294	3.0	51278	2.2	44348	1.9
	Gampaha	26847	1.2	16521	0.7	48187	2.1	103257	4.5	76410	3.3	55070	2.4
	Kalutara	12660	1.0	7791	0.6	25563	2.1	48692	4	36032	3.0	29215	2.4
North central	Anuradhapura	12244	1.4	7535	0.9	20378	2.4	47091	5.5	34847	4.1	23289	2.7
	Polonnaruwa	7340	1.8	4517	1.1	11010	2.7	28231	7	20891	5.2	12583	3.1
Eastern	Ampara	8425	1.3	5185	0.8	12703	2	32405	5	23980	3.7	14517	2.2
	Batticaloa	7509	1.4	4621	0.9	8454	1.6	28880	5.5	21372	4.0	9662	1.8
	Trincomalee	2458	0.7	1513	0.4	4765	1.3	9455	2.5	6997	1.9	5446	1.4
Uva	Moneragala	4078	0.9	2509	0.6	7214	1.6	15683	3.5	11606	2.6	8245	1.8
	Badulla	9498	1.2	5845	0.7	14775	1.8	36531	4.5	27033	3.3	16885	2.1
Southern	Galle	8259	0.8	5082	0.5	18529	1.8	31764	3	23505	2.2	21176	2
	Hambantota	8531	1.4	5250	0.9	16705	2.8	31813	5.5	24282	4.1	19091	3.2
	Matara	6313	0.8	3885	0.5	14729	1.8	24279	3	17966	2.2	16833	2.1
Northern	Jaffna	9095	1.6	5597	1.0	8978	1.5	34980	6	25885	4.4	10261	1.8
	Kilinochchi	2348	2.1	1445	1.3	1581	1.4	9032	8	6684	5.9	1806	1.6
	Mannar	644	0.7	396	0.4	555	0.6	2477	2.5	1833	1.9	634	0.6
	Mulativu	597	0.7	368	0.4	1029	1.1	2297	2.5	1700	1.9	1176	1.3
	Vavuniya	5351	3.1	3293	2.0	3722	2.2	20580	12	15229	8.9	4253	2.5
Central	Kandy	12466	1.0	7671	0.6	25891	1.9	47946	3.5	35480	2.6	29590	2.2
	Matale	6269	1.3	3858	0.8	11139	2.3	24110	5	17841	3.7	12730	2.6
	Nuwaraeliya	7349	1.0	4522	0.6	12860	1.8	28264	4	20915	3	14697	2.1
Sabaragamuwa	Kegalle	10876	1.3	6693	0.8	15226	1.8	41830	5	30954	3.7	17401	2.1
	Ratnapura	11256	1.0	6927	0.6	22728	2.1	43292	4	32036	3.0	25975	2.4
North Western	Kurunegala	18841	1.2	11594	0.7	36071	2.2	72463	4.5	53623	3.3	41224	2.6
	Puttlam	8890	1.2	5471	0.7	15424	2	34191	4.5	25301	3.3	17627	2.3

Note: Counms (i) Inpatients per year due to Direct health effect, (ii) Inpatients per year due to health spill overs, (iii) Outpatients per month after disaster in panel A and B respectively for flood and drought. % columns give the percentage of district population and depicted in maps in appendix 13 and 14.

Table 8: Public health cost of flood and drought (USD)

Province	Flood						Drought						Total health cost due to flood and drought	Per capita Cost
	(i)		(ii)		(iii)		(i)		(ii)		(iii)			
	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private		
Central	285023	321026	175398	197554	64094	191885	1096241	1234714	811218	913688	73250	233771	5,597,862	2.2
Eastern	287034	161560	176636	139304	47720	99701	1103977	870652	816943	644283	54537	121464	4,523,810	2.9
North Central	250955	241030	154434	148326	36165	120722	965213	927040	714258	686010	41332	147074	4,432,559	3.5
North western	825131	341294	507773	210027	173017	198056	3173579	1312671	2348449	971376	197734	241289	10,500,396	4.4
Northern	241890	221974	148856	136600	43463	61018	930348	853748	688457	631773	49672	74337	4,082,135	3.9
Sabaragamuwa	207922	272390	127952	167625	34639	145979	799700	1047655	591778	775265	39587	177844	4,388,336	2.3
Southern	263945	284339	162428	174978	24771	192166	1015174	1093612	751229	809273	28310	234113	5,034,339	2.0
Uva	305953	167086	188279	102822	59253	84574	1176743	642640	870790	475554	67717	103035	4,244,445	3.4
Western	364949	707978	224584	435679	74522	432902	1403651	2722991	1038702	2015013	85168	527398	10,033,537	1.7
Total	3032802	2718678	1866340	1712916	557644	1527001	11664626	10705723	8631823	7922235	637308	1860324	52,837,420	2.6

Note: The coulums in the table show (i) Inpatient cost per year due to Direct health effect, (ii) Inpatient cost per year due to health spill overs, (iii) Outpatient cost per month after disaster. Currency conversion is 1 USD=130n Sri lanka Rupees which is as of the exchange rate in 2013. See appendix 15 and 16 for district level cost in Sri Lankan Rupees.

Figure 1: Total Annual health burden of Flood and Drought (USD)

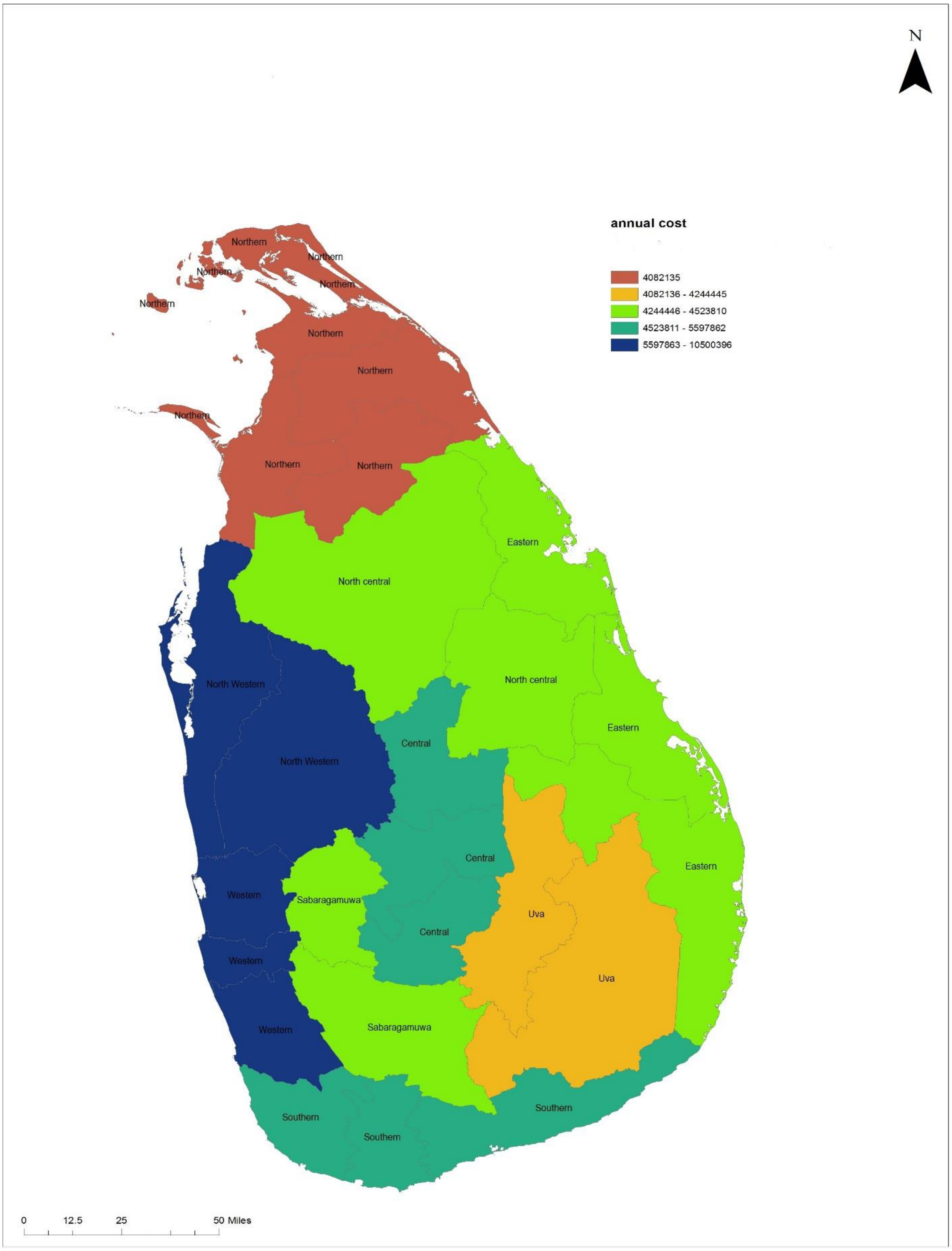
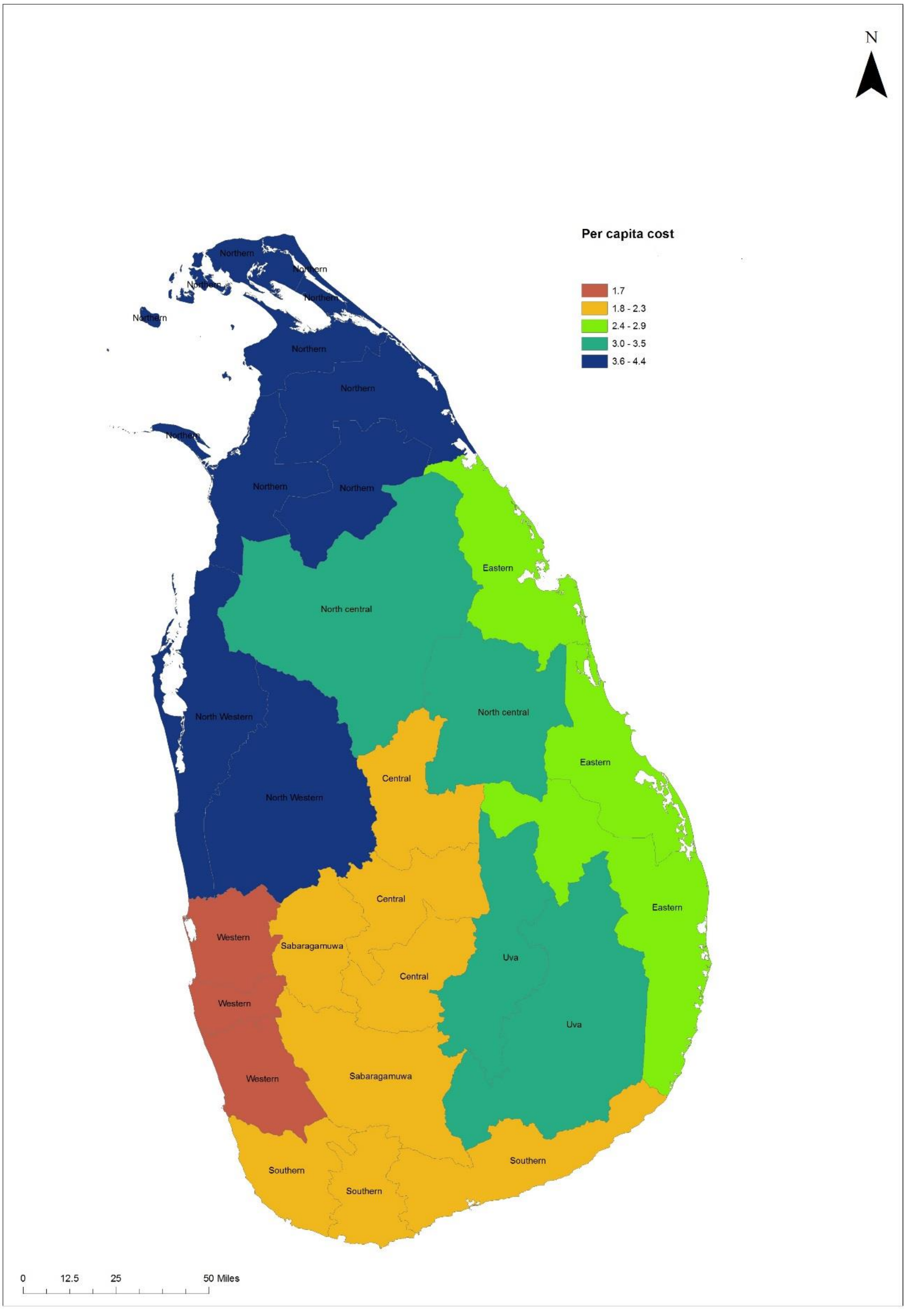


Figure 2: Total annual per capita health burden (USD)



List of Additional Tables Available in Online Appendix

The online appendix is posted at:
https://sites.google.com/site/noyeconomics/research/natural-disasters

Appendix 1: Epidemiological Literature on the links between disasters and diseases
Appendix 2: Agricultural-ecological regions in Sri Lanka
Appendix 3: Selected cases of notifiable diseases in Sri Lanka
Appendix 4: Chronic illnesses in Sri Lanka
Appendix 5: Seasonality of Diseases-2012
Appendix 6: Seasonality of Diseases 2013
Appendix7: Monthly reported Dengue cases in Sri Lanka
Appendix 8: District level per capita public health expenditure (Rs.)
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Appendix 10: Heath effects of flood: inpatient treatment per year using self-reported flood exposure(restricted model)
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Appendix 12: Public Health cost of flood by districts (Million SLR)
Appendix 13: Private Health cost of drought by districts (Million SLR)
Appendix 14: Inpatient, outpatient private and public health cost (Percentage of total cost)

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