Peasant Households and Pandemic Viral Diseases

Feuerbacher, Arndt and McDonald, Scott and Thierfelder, Karen

Agricultural and Food Policy Research Group, University of Hohenheim, Germany, Department of Agricultural Economics, Humboldt-Universität zu Berlin, Germany, Economics Department, US Naval Academy, United States

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Feuerbacher, Arndt[a], McDonald, Scott[b] and Thierfelder, Karen[c]

[a] Agricultural and Food Policy Research Group, University of Hohenheim, Germany;
E-mail: a.feuerbacher@uni-hohenheim.de
[b] Department of Agricultural Economics, Humboldt-Universität zu Berlin, Germany;
E-mail: jrs.mcdonald@gmail.com
[c] Economics Department, US Naval Academy, United States;
E-mail: karen.thierfelder@gmail.com

Abstract

Outbreaks of infectious diseases are particularly devastating for developing countries and the poor: they deplete, through premature death and morbidity the primary asset of the poor – their labour – in economies with the least developed health care systems. This study examines how peasant households, who are simultaneously producers and consumers, might adapt to the impact of a pandemic. The analyses indicate that the dual role of peasant households allows them to mitigate some of the adverse impacts of a coronavirus pandemic, and thereby offset some of the economic effects. Critical to this is the ability of peasant households to transfer labour between agricultural activities and social reproduction; and this happens whenever in the year a pandemic occurs. But it is noteworthy that the changes in consumption and production patterns differ according to the timing of the pandemic.

Keywords: Peasant households; Seasonal labour; Labour-Leisure trade-off; Pandemics; Economy-wide modelling.

1. Introduction

Peasant households account for a large proportion of rural populations in low and lower-middle income countries. Most poor households are rural (Castañeda et al., 2018), and most rural households are peasant households, whose primary asset is their labour, which makes them heavily dependent upon the physical labour of members of the household to sustain their livelihoods. Pandemic diseases attack the primary assets of poor households through premature deaths and morbidity, which implies a likelihood for serious adverse economic implications, over and above the social and psychological trauma. It might be expected that peasant households may be especially susceptible because of the seasonal pattern of labour demand driven by the biological nature of agricultural production systems.

Historical records indicate the periodic occurrence of pandemics from the ancient world and Middle Ages (Huff, Beyeler, Kelley, & McNitt, 2015). Reductions in the population due to The Black Death (1347 to 1353) was arguably the largest demographic shock experience by Europe: the death of between 17 and 28 million people led to farmland abandonment and declines in cereal production in many parts of medieval Europe (Yeloff & van Geel, 2007) and has been associated with serious social unrest.[1] The Spanish flu (H1N1) was the deadliest viral pandemic in modern history killing an estimated 50 to 100 million people in the 1920s (Morens & Fauci, 2007). Recently, zoonotic viral diseases have emerged as a threat, along with concerns that a trend is developing (Lee & Hsueh, 2020).

Seasonal fluctuations in labour demand are a feature of all agricultural systems. In developed market economies production systems have evolved to smooth out seasonal labour demands; these include the use of labour-saving machinery, contractors and phytosanitary chemicals. But many peasant households are constrained in their ability to adopt such production systems by, *inter alia*, lack of capital, imperfect credit markets and their small scale of production. Consequently, the seasonal variations in labour demand result in periods of peak demand, e.g., planting, weeding and harvest, and periods of slack demand during which various strategies may be adopted to smooth out the demand for labour, e.g., small-scale domestic production[2] and temporary migration. Given fluctuations in seasonal demand for labour, the

[1] For instance, the Peasant Revolt in the UK (1381) has been attributed to the impact of the Black Death on the relative prices of land and labour. However, the latter part of the 14th century was a period of radical social change so distinguishing between difference causes is difficult.

[2] Historic examples of such small-scale domestic production can be found in many countries, e.g., the production of Harris tweed by crofters in Scottish Hebrides during the winter.

economic impacts of a pandemic may vary depending on the seasons in which the pandemic arises.

The study reported in this paper explores how peasant households might respond to mitigate the economic impacts of a pandemic and how differences in the seasonal patterns of a pandemic impact upon the welfare of peasant households. The model used defines peasant households as optimising agents who make non-separable production and consumption decisions: the optimum combinations of agricultural production, social reproduction (of services), consumption of goods and leisure by each household are made jointly. The analyses are conducted over time to distinguish between the mortality and morbidity impacts during the period of the pandemic and the longer terms effects of premature deaths on welfare in subsequent periods, e.g., the reduction in cultivated area due to a smaller labour force. The pandemic disease simulated is inspired by the COVID-19 pandemic, but the economic implications are relevant to other pandemic viral diseases that may have similar seasonal mortality and morbidity patterns.

The results demonstrate that peasant household may adopt strategies that can cushion the welfare implications of a pandemic by adjusting the distribution of labour services between agricultural activities and social reproduction. The results also demonstrate that the season in which a pandemic disease occurs can produce different adjustments in production and consumption decisions as part of the process of mitigating the economic impact of a pandemic.

The rest of the paper is organised as follows. The next section explores the defining characteristics of peasant households and provides a basis for how they are modelled. This is followed, section three, by a brief review of pandemic viral diseases with attention to COVID-19. The key characteristics of the model are described in section 4 after a description of the data used to calibrate the model. Section five defines the simulations implemented and reports the analyses of the results. The paper finishes with concluding comments that identify areas that justify further research and some of the policy implications that arise from the analyses.

2. Peasant Households

The socioeconomic analyses of peasant (farm) households has long interested social anthropologists and development economists, e.g., Chayanov (1986)[3], Mintz (1973) and Wolf (1966). Among the themes that emerge are that peasant societies and households are not static, uniform or isolated. The evolution of peasant societies is a long-term consideration while not being isolated they engage with markets and in exchange; the extent of engagement depending, at least in part, on the 'stage' of evolution. A critical feature of peasant farm households is they are simultaneously households and productive activities[4]; peasants must manage both the farm activity and the household.[5]

Schultz's hypothesised that peasants were 'poor but efficient' (Schultz, 1964), where the analyses presumed that peasants were profit maximising farmers making separable production and consumption decisions. This 'Chicago' approach 'ensures' that peasant farmers are producing on the production possibility frontier with a socially optimal use of inputs and output mix given perfect knowledge and markets. This approach has long been criticised for failing to recognise the constraints imposed on the decisions of peasant farmers due to, *inter alia*, imperfect markets (e.g., Hoff, Braverman, & Stiglitz, 1996), agrarian institutions (e.g., Bardhan, 1989), surplus labour (e.g., Sen, 1966, 1967) and risk (e.g., Lipton, 1968). Moreover, since peasants must simultaneously operate as households and productive activities their production and consumption decisions are non-separable; hence peasant households should simultaneously be agents as activities and households in economic models (see Aragie, 2014; Löfgren & Robinson, 1999; McDonald, 2010).

<u>Peasant Households in Whole Economy Models</u>

If peasant households are included as both activities and households the underlying model should embody properties found in the models developed by Chayanov (1986), Sen (1966), Mellor (1963), Lipton (1968), Barnum and Squire (1979), Becker (1965) and Lopez (1986). Peasant households that operate as both households and productive activities make decisions over consumption, including leisure and therefore the supplies of labour to productive activities,

[3] Chayanov's works date from the early 20th century but were not available in English until the 1980s.
[4] The term 'activities' is used in preference to a common term 'enterprises'; the term 'enterprises' is used in national accounts to refer to the institution of incorporated business enterprises.
[5] Ellis(1993) provides an overview of the 'economic models' of peasant (farm) households. The literature on exploitation and subordination of peasants is not explored here (see Ellis(1993), chapter 3 for a brief overview).

and production, including social reproduction, simultaneously and so optimising household utility (Becker 1965; Michael & Becker, 1973; Lopez, 1986). Such peasants may be optimising, while not being ‘pure‘ profit maximisers in production. They may, *inter alia*, be constrained by imperfect knowledge and markets (Hoff et al., 1996), risk averseness (Lipton, 1968), and averseness to ‘drudgery’ (Chayanov, 1986). In such models peasant households can optimise one, or more, household objectives, i.e., act as rational economic agents (Lipton, 1968), while not being simple (separable) profit and utility maximisers. This is consistent with empirical evidence that peasants are responsive to market signals, changes in market arrangements, e.g., reductions in trade and transport costs, and changes in technology. Similarly, peasant households are not isolated from labour markets and can interact with markets both to supply labour to other activities other than their own productive activities, and to demand labour in peak seasons. Peasant households must also adjust to the biological nature of agricultural production and seasonal fluctuations in demand for labour; thereby reflecting that with “agriculture being a seasonal operation, it is somewhat misleading to speak in terms of a homogeneous unit of labor. A unit of labor at the time of harvesting is not replaceable by a unit of labor at a slack period” (Sen, 1966, p. 440). This may be important when shocks, such as a pandemic, may arise during seasons with high demands for labour.

3. Pandemic Diseases and COVID-19

Periodic pandemics and disease outbreaks are part of human history. The Black Death in the mid-14th century and the Spanish flu (H1N1) in the 1920s are the best known and it has been argued that both had long term socioeconomic implications; the Black Death has been linked with the wider emergence of labour markets (Voigtlander & Voth, 2013), while the Spanish flu has been linked to the development of healthcare systems. With the development of antibiotics, bacterial pandemics could be countered relatively easily, although the development of antimicrobial resistance is undermining interventions (see Ahmed et al., 2018). Recently the emergence of zoonotic viral diseases, e.g., HIV/AIDS, Ebola and coronaviruses (MERS and SARS-CoV-1 and 2) has become an issue (Lee & Hsueh, 2020).[6] It has been argued that the continued loss of biodiversity and wildlife habitat, increases the probability of zoonotic diseases emerging (Ostfeld, 2009; Zumla et al., 2017).

Pandemics increase mortality and morbidity and require diverting resources to public health interventions from other economic activities. It has been estimated that the Spanish flu reduced the agricultural workforce in British India by 8.3% (Schultz, 1964)[7], and that province-level reductions in land use were up to 28% (Sen, 1967). The Ebola epidemic in West Africa in 2014-15 coincided with the rice harvest season in Liberia. This increased labour shortages, through fears of contagion associated with congregating in groups, resulting in depressed levels of rice production and sharp increases in rural poverty (La Fuente, Jacoby, & Lawin, 2019).

<u>Compartmental epidemiological model</u>

In the subsequent analysis, a compartmental model is employed to generate different pandemic scenarios that could impact a peasant economy. Compartmental models have long been used in epidemiology (Kermack & McKendrick, 1927); and are well understood. While compartmental models may be a strong abstraction from the full complexity and heterogeneity of a pandemic, such as COVID-19, they provide a systematic, and well understood method to estimate the dynamics and severity of outbreaks at the national level.

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6 Some research suggests that the 'Russian' flu epidemic may have been caused by a coronavirus that transitioned from cattle (Vijgen et al., 2006).

7 Sen (1967) argues that Schultz overestimated death rates by not allowing for natural increases in population.

The mortality and morbidity effects of COVD-19 used for this study are estimated using a generalized compartmental SIR (Susceptible-Infected-Recovered) (Noll et al., 2020).[8] The model is stratified by age-groups and compartments that represent the spread and development of infections. The compartments are susceptible (S), exposed (E), infected (I), the recovered (R), hospitalized (H), and critical (C). The model is driven by a reproductive number, R0, i.e., the average number of persons infected by each infectious individual. The probabilities of transitioning between compartments are age specific and the model allows for seasonal forcing[9]. Deaths occur from the C compartment; those entering C are admitted to an Intensive Care Unit (ICU), with preference granted to younger persons, or move to an overflow (O) compartment, if ICU space is full. The severity of ICU overflow can be modelled through a multiplicative factor to the fatality rate of persons with critical conditions, but without access to ICU treatment. Persons from C critical status either recover (R) or die (D).

The model has a browser-based user interface and the pre-set parameters are estimated from empirical data. All model parameters (latency, infectious period, the reproductive number) and the country specific data (demographics and age profile) can be specified by the user (see Noll et al. (2020), for more details on the model employed).

4. Data and Model

Model

The computable general equilibrium (CGE) model (Feuerbacher, 2019; Feuerbacher, McDonald, Dukpa, & Grethe, 2020) is a variant of the STAGE model (Aragie, McDonald, & Thierfelder, 2016; McDonald & Thierfelder, 2015) implemented in a recursive dynamic mode (McDonald & Thierfelder, 2020). The developments include modifications to the production system and utility functions, which are combined with factor market clearing at the level of the household and (incorporated business) enterprises.

Production is modelled as a five-level system of nested CES and Leontief production functions (see Fig. 1 where 0 (zero) in an arc indicates a Leontief function and σ a CES function). Land inputs are modelled as CES aggregates of land, chemical fertilisers and manure.

[8] Detailed documentation is available on the model's website (www.covid19-scenarios.org/about).

[9] Seasonal forcing allows for differences in impacts due the season of infection. Given the limited understanding of COVID-19 the feature is not used for this study.

Capital inputs are modelled as CES aggregates of the different type of capital, and aggregate capital-labour is defined as a CES aggregate of capital and aggregate labour. Aggregate labour is a CES composite of seasonal (shaded) and permanent (non-seasonal) labour, which is a CES aggregate of skilled and unskilled labour. This is a novel formulation for a production system in a CGE model (Feuerbacher et al., 2020). Seasonal labour is only used by agricultural activities and the monthly demand for labour by agricultural activities is defined. There are no direct substitution possibilities for labour supplied in different seasons; but there are indirect substitution possibilities through labour leisure trade-offs.

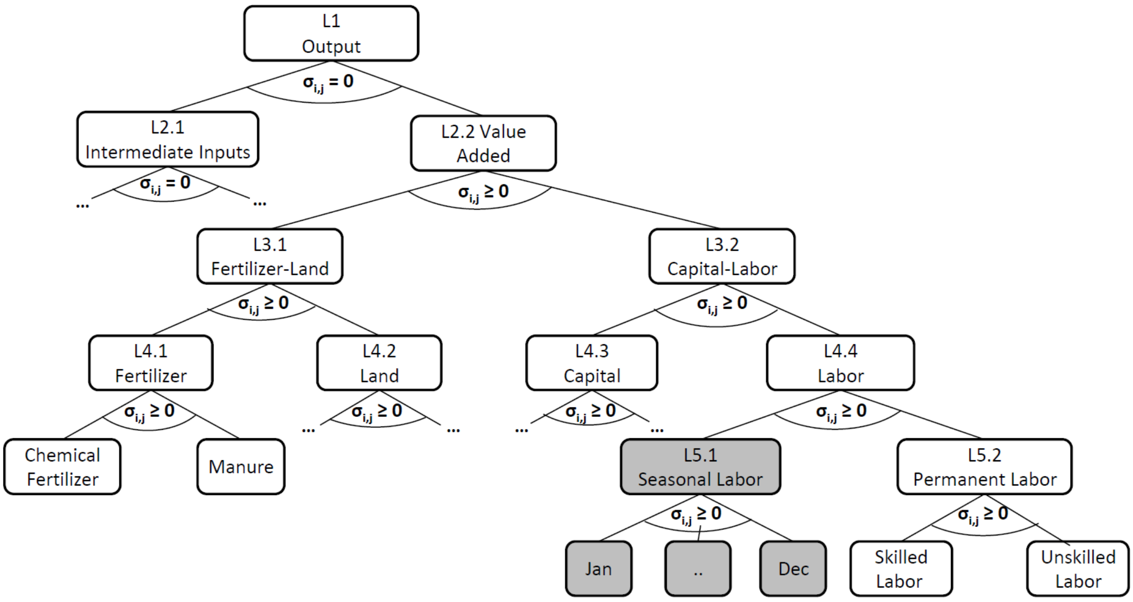

Fig. 1 - Production System

Source: Feuerbacher et al., 2020

Each household has a paired activity that produces household specific social reproduction and leisure, using labour services owned by the household. The production functions are CES aggregates of permanent and seasonal labour, i.e., there are labour substitution possibilities. By defining activities that produce commodities outside the production boundary as household specific, i.e., they can only be produced and consumed by the household, there are uniquely defined prices for commodities and services produced inside and outside the boundary. This approach ensures unique prices, in accord with the SNA. It is a generalization of a method used by Fontana and Wood (2000).

Labour market clearing, in quantities, is defined as $\sum_a FD_{f,a} \leq \sum_{ins} FSI_{ins,f}$ where $FD_{f,a}$ is the factor, *f*, demanded by activity, *a*, and $FSI_{ins,f}$ is the factor supplied by institution, *ins*, including households, which endogenizes the distribution of income (Aragie et al., 2016). This means that each household can supply its labour to its own agricultural and social reproduction/leisure activities and the labour market. Labour market clearing at the household level ensures that labour services used by activities within the System of National Accounts (SNA) production boundary, and outside the production boundary for social reproduction and leisure, cannot exceed those available to the household. This formulation endogenizes the distribution of income, i.e., the distribution of earned income among households is a variable dependent on the quantities of labour each household sells to activities.

The demand system is a nested three level CES-LES[10]-CES utility function whereby households choose optimum mixes of commodities and social reproduction/leisure subject to prices and the constraints of preferences, income and labour resources. In the first (CES) level each household trades-off aggregate leisure/social reproduction services and aggregate consumption. At the second (LES) level households determine the optimum consumption levels of aggregate commodities, e.g., processed food, services, other goods, subject to minimum (subsistence) levels of consumption. At the third (CES) level households choose optimum mixes of 'natural' commodities in the aggregate commodities. The income elasticities of demand for commodity groups at the LES level were estimated using cross-sectional household data from the 2012 Bhutan Living Standard Survey (Feuerbacher, 2019).

Data

The data are a Social Accounting Matrix (SAM), with satellite accounts for labour quantities, for Bhutan in 2012 (Feuerbacher, Dukpa, & Grethe, 2017). The main body of the transactions matrix follows standard national accounting price conventions (valuations are in basic and purchaser prices) with inter-industry accounts recorded in supply and use format for all transactions within the SNA production boundary. Distinctive features of the SAM include detailed accounts for agriculture by three agroecological zones[11] (AEZs) reflecting variations in climate and altitude and differences in growing conditions, the monthly demand for farm labour types by activities and the recording of activities for social reproduction/leisure that are outside the SNA production boundary.

[10] LES is a Linear Expenditure System.
[11] AEZ1 is the humid subtropical zone below 1,200m; AEZ2 is the dry subtropical zone between 1,200 and 1,800m; AEZ3 is the temperate zone above 1,800m

The rural labour market is dominated by seasonal farm labour types segmented by the three AEZs. Other workers in rural areas include teachers, shop owners, etc. Non-farm labour is classified as unskilled and skilled (permanent) labour, which is demanded by agricultural, food processing, manufacturing and service activities and social reproduction. There are five land accounts (rainfed, irrigated, orchard, pasture and forestland) each sub-divided by AEZ. There are five capital factors: two livestock capital accounts (cattle and other animals), and three physical capital factors (private capital, hydroelectric and informal capital). There are unique 'production functions' for the generation of new capital by each type of capital. Ownership of factors by institutions (agricultural household and incorporated business enterprise) is identified.

Crops are cultivated in different seasons or with different cropping patterns, e.g., double or single cropping of maize; these activities were disaggregated accordingly. Cropping activities account for 52% of the output of seasonal activities, by value, and 43% of total person-days. Rice production is labour intensive - 250 person-days per hectare – and accounts for ~38% of cropping labour. There are 37.9 million person-days provided by some 170,000 farmers, i.e., an average of 225 working days per person; this excludes labour used for social reproduction and leisure. Overall, employment in seasonal activities accounts for 48% of Bhutan's labour days. Table 1 reports the shares in total output and required person-days for seasonal activities (those that use seasonal labour).

Households are classified as agricultural if at least one household member is reported to work within agriculture. Agricultural households are sub-divided by AEZs and access to land, i.e., farm and landless households. The accounts for social reproduction and leisure cannot be separated in the source data, therefore they are recorded treated as a single account – 'leisure'. The use of person-days for seasonal labour and leisure for the three AEZs are reported in Fig. 2, with the number of person-days absorbed by cropping, livestock, non-farm and leisure activities summarised for each month. The patterns of demand differ markedly across activities, particularly for cropping activities with rigid demand. The potential seasonal labour bottlenecks are driven by the paddy transplanting and harvesting seasons, which vary by AEZ, e.g., in AEZ1 transplanting is in June-July and harvesting in November-December. Livestock activities, comprising more than a third of total seasonal labour (Table 1), and leisure have slightly flexible labour demand. Nonfarm activities have highly flexible labour demand and follow a counter-cyclical pattern, i.e., their labour demand is lowest during peak periods and highest during lean seasons, such as during the winter months in AEZ3.

Table 1. Seasonal activities: 2012 Social Accounting Matrix for Bhutan

Activity	%-Share in total seasonal output value	Person-days (in thousand)	Share in total person-days employed in production	Seasonal labour substitution elasticity σ
Milled, rice	12.7	6,065	16.0	0
Double cropping of maize	1.8	1,102	2.9	
Single cropping of maize	5.2	2,971	7.8	
Other cereals and oilseeds	2.5	1,100	2.9	
Vegetables - first season	4.5	786	2.1	
Vegetables - second season	4.5	1,107	2.9	
Potato - first season	5.9	1,411	3.7	
Potato - second season	0.2	96	0.3	
Spices	4.3	453	1.2	
Fruits	10.1	1,032	2.7	
Total cropping activities	51.6	16,123	42.5	
Cattle husbandry	9.6	8,249	21.8	0.1
Other animals	5.3	2,049	5.4	0.1
Dairy production	12.5	3,914	10.3	0.2
Total livestock activities	27.4	14,212	37.5	
Other cereal milling	1.0	146	0.4	1.5
Cereal processing	2.6	345	0.9	1.5
Ara[a] production	4.0	786	2.1	1.5
Total food proc. activities	7.6	1,277	3.4	
Community forestry	8.6	4,164	11.0	1.5
Textile weaving	4.8	2,123	5.6	1.5
Total non-farm activities	13.4	6,287	16.6	
Total seasonal activities	100.0	37,899	100.0	
Total seasonal leisure		14,655		0.2

Note: Each seasonal activity is further disaggregated by agroecological zones (AEZ).
[a] Ara is a traditional home-brewed alcoholic beverage made from cereals
Sources: Feuerbacher et al., 2017

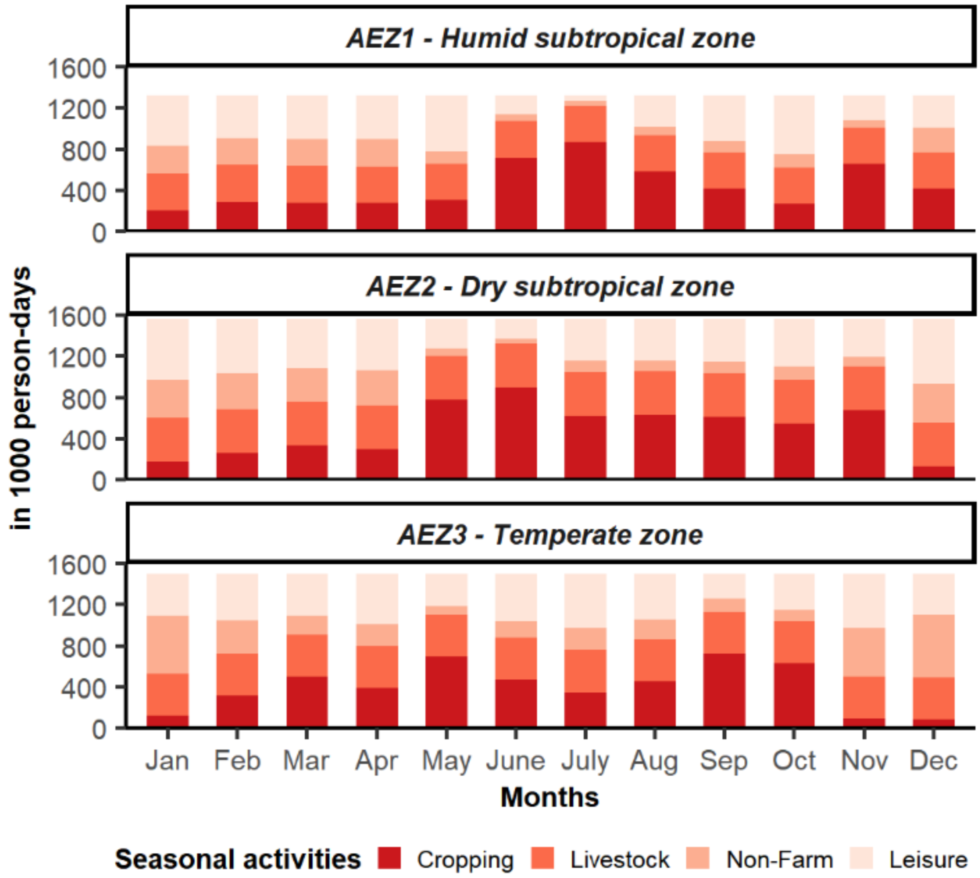

Fig. 2 - Seasonal labour demand by AEZ (in 1000 person-days per month)

Source: Feuerbacher et al., 2020

<u>Model Calibration</u>

The model requires exogenous parameters that govern the responsiveness of agents to changes in (endogenous) model variables and exogenous shocks. Given the nature of the shocks simulated – short term reductions in labour – the abilities of peasant households to transfer labour from leisure/social reproduction (leisure) to agricultural production (work) are critical. This section emphasises the parameters that control this labour transfer.

The number of days worked (H) is imputed as 225 days per year from the total days worked by agricultural workers in Bhutan. The annual disposable time-endowment for households (*T*) is set at 312 days per year;[12] the amount of 'leisure' time (*F*) is the difference.

[12] Defining the lower bound for *T* when there is zero leisure at peak labour demand gives range from 262 (in AEZ3) to 298 days (in AEZ1). 312 days allows for a minimum amount of 'leisure' for social reproduction.

A plausible income elasticity of labour supply, $\varepsilon_{H,Y}$, is given by $\varepsilon_{H,Y} = H/T - 1$ (Boeters & Savard, 2013). The substitution elasticity for the labour-leisure trade-off, $\sigma_{lei,X}$, can be defined as $\sigma_{lei,X} = 1 - \varepsilon_{H,w}/\varepsilon_{H,Y}$, where $\varepsilon_{H,w}$ is the (unknown) wage elasticity of labour supply $\varepsilon_{H,Y} = H/T - 1$ (Boeters & Savard, 2013). Setting the wage elasticity of labour supply to 0.15 (Goldberg, 2016) gives elasticities of labour-leisure substitution of 1.54 for agricultural and 2.00 for non-agricultural households. Sensitivity analysis demonstrates the robustness of model results across a range of elasticities. The implicit income elasticity of labour supply for agricultural households is -0.28 ($\varepsilon_{H,Y} = 225/312 - 1$) and -0.15 for non-agricultural households. The calibrated values for $\varepsilon_{H,Y}$ are within the range reported by Bargain and Peichl (2016), while estimates based on shadow-wage data for low-income countries are higher (Barrett, Sherlund, & Adesina, 2008; Jacoby, 1993) , i.e., lower quantities of leisure.[13] The substitution elasticities for different labour types (skilled, unskilled or seasonal) in the production of leisure are set at 0.50. The intra-seasonal substitution of leisure is set to 0.20, in recognition of leisure being inclusive of social reproduction, which is within the range of empirical estimates between 0.01 – 1.20 (Feuerbacher et al., 2020).

5. Analyses

The CGE model simulates a series of COVID-19 scenarios over 10 years. The pandemic is assumed to impact in one wave: in the first year the pandemic has mortality and morbidity effects that are estimated using the SIR model (see below for details), while in subsequent years the effects are the reductions in population due to the pandemic. The cost of increased health expenditure is also included.

Scenarios

The SIR model described above is used to simulate the morbidity and mortality outcomes from COVID-19 outbreak. The morbidity and mortality effects are estimated for R0 values of 1.5, 2.0, 2.5 and 3.0, reflecting the range reported (Liu, Gayle, Wilder-Smith, & Rocklöv, 2020), and associated model parameters. Table 2 reports the model parameters for the core scenario, which is based on a conservative R0 of 2, which also reflects the rural and scattered settlements in Bhutan. The demographic data used for all scenarios are reported in Table 3.

[13] Lower quantities of leisure will magnify the effects of labour supply shocks.

Table 2 - Model parameters used in the core COVID-19 scenario

Model parameter	Value	Unit / Description
Initial number of cases	10	Persons
Imports per day	1	Daily number of infected persons entering the country from outside
Annual average R0	2.0	Average number of secondary infections per case.
Latency period	3	Days
Infectious period	3	Days
ICU capacity	96	Beds
Hospital stay	3	Days
ICU stay	14	Days
Severity of ICU overflow	3	Multiplicative factor to fatality rate of persons with critical status but without ICU access

Source: Noll et al. (2020), authors' assumptions and Bhutanese news reports (The Bhutanese, 2020)

The reader should note, that the subsequent analysis uses Bhutan as an illustrative case without the intention to reflect the current observed pandemic events and policy responses in the country. The generated scenarios deliberately abstract from the actual situation in Bhutan. The Kingdom of Bhutan has, by time of this writing, shown a very successful response to COVID-19 comprising random testing and rigorous screening of persons entering the country (which so far have been the only responsible source for the 33 positive cases as of 29th of May 2020).

Table 3 - Demographics for Bhutan and age-group specific disease severity

Age group	Population (projected for 2020)[a]	Confirmed[b] % of total pop.	Severe[c] % of confirmed	Critical[d] % of severe	Fatal[d] % of critical
0-9	118,012	5	4.8	5.0	30.0
10-19	133,528	5	1.1	10.0	30.0
20-29	147,116	10	10.4	10.0	30.0
30-39	133,260	15	18.8	15.0	30.0
40-49	87,107	20	21.5	20.0	30.0
50-59	58,464	25	30.8	25.0	40.0
60-69	38,924	30	38.0	35.0	4.0
70-79	20,906	40	39.2	45.0	50.0
80+	9,368	50	34.4	55.0	50.0

Sources: [a] National Statistics Bureau of Bhutan (NSB, 2019); [b] Pre-set assumptions by the SIR model; [c] Mean of Riccardo et al. (2020) and Verity et al. (2020) adjusted for under-ascertainment; [d] Epidemiological characteristics reported by Chinese Center for Disease Control and Prevention (The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team, 2020)

Four timings of the core COVID-19 scenario (postfix R2.0) are simulated, which are all linked to the seasonality of labour demand: agricultural off-season (Winter_R2.0), rice transplanting season (Plant_R2.0), rice weeding season (Weed_R2.0) and rice harvest season (Harvest_R2.0). Scenario Winter_R2.0 starts in December, of the previous year, with infections peaking in February and March; Plant_R2.0 starts in March and peaks in May and June;

Weed_R2.0 starts in June and peaks in Aug and September; and Harvest_R2.0 starts in September and peaks in November and December. Fig. 3 illustrates the daily number of infections (left axis and line) and changes in farm labour supply (right axis and shaded blocks) of the four simulated outbreaks.

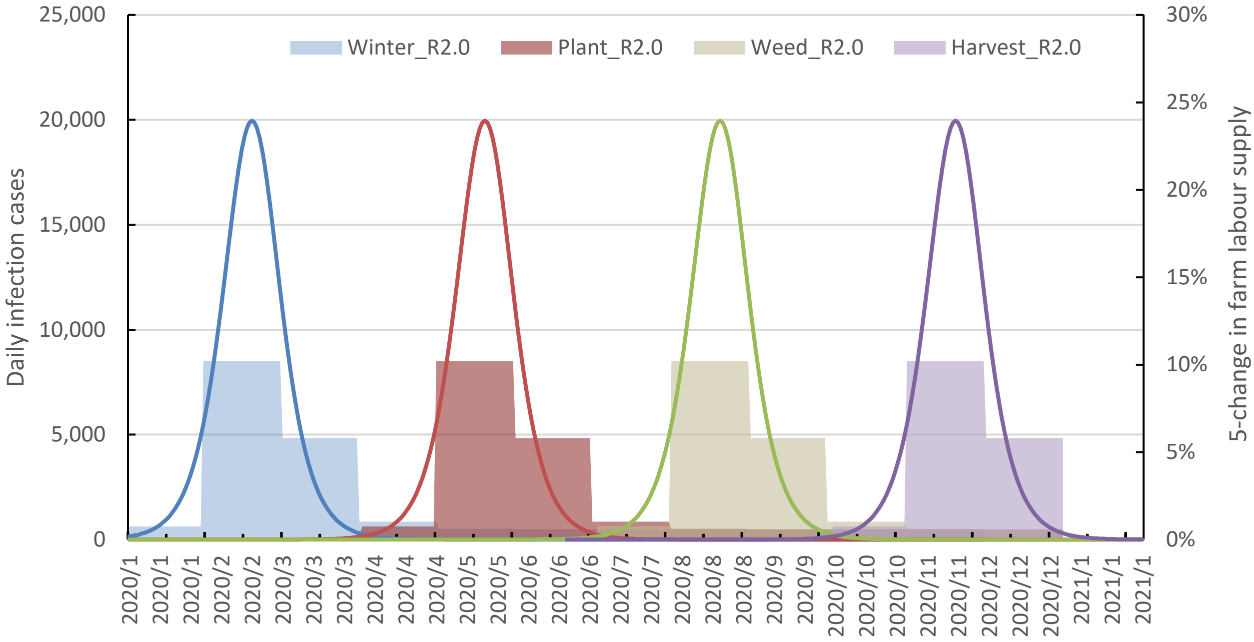

Fig. 3 - Daily Number of Infections (Lines and left axis) and Change in Farm Labour Supply (Area and right axis)

Source: Authors estimates based on the SIR model (Noll et al., 2020)

The SIR model reports four categories of disease severity: non-severe, severe, critical and fatal. The number of labour days lost due to the COVID-19 morbidity and mortality effects depend on the degree of disease severity. To account for the range of symptoms the non-severe category is subdivided into three categories: asymptomatic, mild and moderately severe, giving six categories of disease severity. It is assumed that 20% of infections are asymptomatic (Mizumoto, Kagaya, Zarebski, & Chowell, 2020), 60% have mild symptoms, 17% have moderately severe infections and 3% with severe infections.[14] The proportions and numbers of infections in each category and the numbers of labour days lost for the 20-69 age group given an R0 of 2.0 are reported in Table 4.

[14] This reflects the large proportion of young people in Bhutan.

Table 4 - Disease Severity and Labour Days Lost (R0 = 2.0)

Disease severity	Description	% of all infection cases	Labour days lost per infected person	Number of infections (20-69 years)	Labour days lost – Year 1 (20-69 years)	% of total labour days lost (20-69 years)
Asymptomatic	No symptoms	19.9	0	75,182	0	0.0
Mild		59.6	5	225,546	1,127,732	37.3
Moderately severe		16.8	14	63,749	892,486	29.5
Severe	Hospitalized	2.8	30	10,482	314,457	10.4
Critical	ICU treatment needed	0.4	60	1,495	89,700	3.0
Fatal		0.6	∞	2,082	596,519	19.7
TOTAL		100.0		378,537	3,020,893	100.0

Source: Authors' estimates based on the SIR model (Noll et al., 2020)

The model is run for 10 years; 'Year 0' is the base year and the pandemic impacts on the economy in 'Year 1'. The simulations used to inform the analyses include four pandemic 'intensities', based on R0 values, with the outbreaks in four different seasons and a 'Business as Usual' (BaU) scenario for which there is no outbreak of the disease.

During the year of the outbreak, the volumes of government health services are expanded to reflect increased need for healthcare (R0 1.5 by 11%; R0 2.0 by 15%; R0 2.5 by 16%; and R0 3.0 by 17%).[15] At the same time the elasticities of substitutions between 'leisure' and aggregate commodities are halved – from elastic to inelastic – to reflect the increased need for carer services within households.

The macroeconomic closure and factor market clearing conditions for the model are:

1. Trade: small country trade assumption (fixed world prices) with the fixed trade balance (in foreign currency units) as fixed share of GDP, with the exchange rate flexible.
2. Investment: investment is a fixed share of GDP in the BaU scenario, i.e., over time, and fixed at the BaU levels in the disease outbreak scenarios, i.e., it is assumed that the disease did not affect expectations; saving rates are flexible.
3. Government: the government expenditures are fixed shares, of domestic final demand and borrowing are fixed; the direct tax rates on enterprises are flexible.
4. Factors: labour is fully employed by activities within the SNA boundary or in leisure/social reproduction but free to move between activities; three types of

[15] The estimation of the respective increase in healthcare cost is documented in appendix A.

fixed capital (private capital, hydroelectric and informal capital) are fixed within each period; other flexible capital types (livestock) are fully employed and mobile; and land use is flexible within each period, i.e., farmers can adjust the area cultivated.

5. Technology: technology, at the aggregate value-added level, is fixed within each time period but is assumed to improve over time.

The recursive dynamic settings assume that investment decisions for new capital goods for period *t* are made at the end of period (*t*-1) and then allocated to activities for period (*t*+1). Each type of capital has a unique (Leontief) cost/production function and the volume of production for each capital type changes in response to the (relative) rates of return to each type of capital. For types of capital that are activity specific, the allocation of new capital to each activity is determined by the (relative) rates of return to each type capital in each activity and is then fixed for that period. The same initial allocation is implemented for flexible types of capital, but they are then mobile.

Labour supplies for each labour types are assumed to grow exogenously at the same rate[16] for all households: skilled labour grew by 1.5% per annum, unskilled labour by 3.5% and agricultural labour by 0.64%. Thus, the shares of each type of labour changed over time.

Technology is assumed to grow exogenously at 1% per annum.

Results

The analyses of the results begin with an overview based on changes at a macroeconomic level. The analyses then move to the implications for households and how, in general, households, especially farm households, respond to the shocks, and then to how productions and consumption decisions differ according to the season in which the pandemic arises. The scenarios were analysed over 10 years for 16 labour supply shocks and Business as Usual (BaU); the reported analyses consider the first 5 years since by year 5 the economy has stabilised. The analyses with respect to households concentrate on the results from the R0 2.0 shock in the (rice) planting season (Plant_R2.0); the analyses of production and consumption concentrates on the four R0 2.0 shocks occurring in different seasons of the year.

[16] The rates were in line with past rates of labour growth, based on population projections (NSB, 2019).

'Macro Level' Results

Fig. 4 reports the results for percentage changes in real GDP for different intensities of the outbreak of the disease (R0 1.5 to R0 3.0) during the planting season over 5 years. During the year of the outbreak real GDP declines by between 0.33% to 0.66% due to morbidity and mortality effects and then recovers, but to a level between 0.01% and 0.12% below the BaU scenario due to the enduring mortality effect. Other summary indicators produce results that convey the same general implications; absorption declines and then recovers, but not fully; as do export and import volumes and household consumption. The patterns of the changes are in line with expectations; this consistency across different intensities of outbreak present a consistent pattern across all the shocks, although the magnitudes of the effects vary.

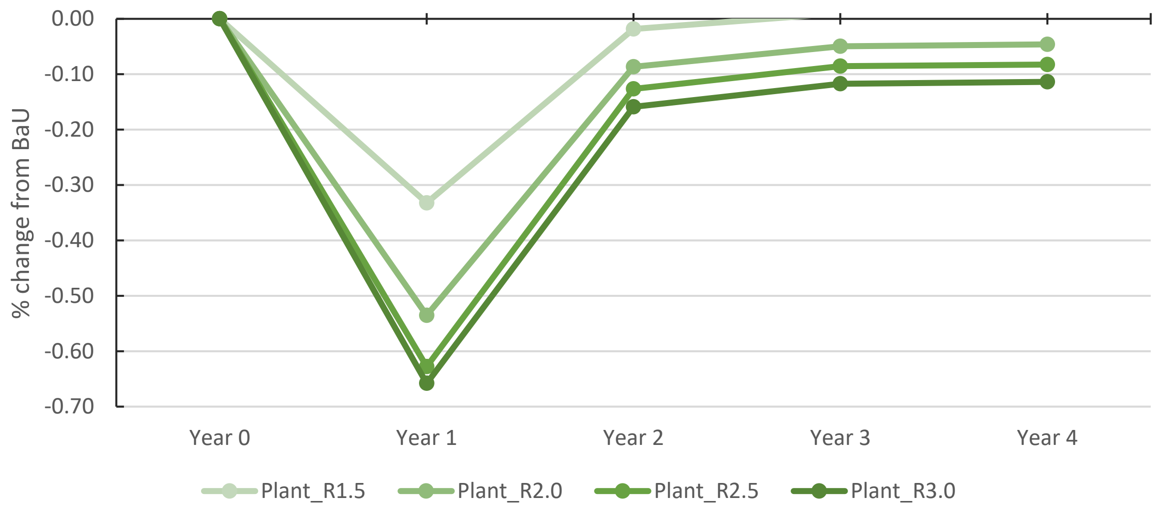

Fig. 4 - Real GDP for Different Intensities of the Outbreak (% change from BaU)

Source: Authors' calculations.

The 'macro' impacts of disease outbreaks occurring in different seasons is illustrated in Fig. 5. The earlier in the year the outbreak occurs the more it causes real GDP to decline in that year, and the more rapidly real GDP recovers, whereas the later in the year the less the within year GDP declines and the slower real GDP recovers. This reflects the fact that the effects of the first two shocks (Winter_R2.0 and Plant_R2.0) are largely played out within one year, whereas the effects of the other two shocks are carried over to the next year. The overall losses of GDP are close, but this feature of the results needs to be borne in mind when evaluating the results. The other summary results display consistent patterns.

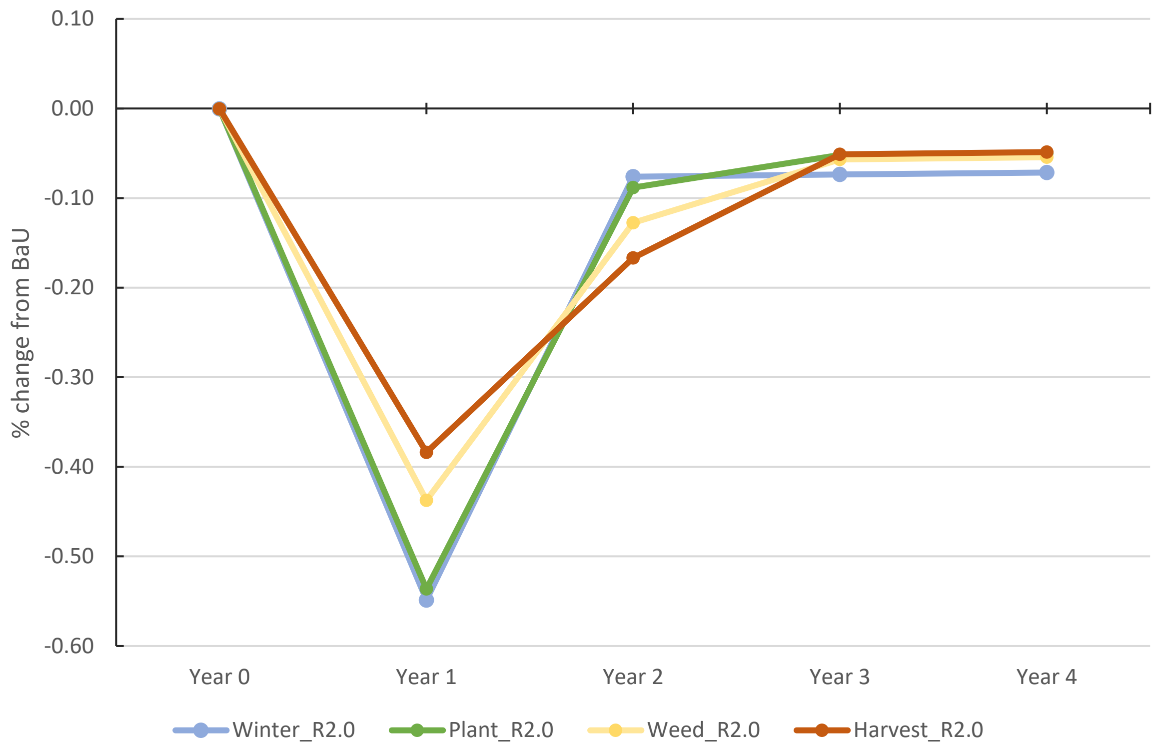

Fig. 5 - Real GDP: Different Season of Outbreak (R0 = 2.0; % change from BaU)

Source: Authors' calculations.

The summary results, and explorations of the micro-level results, allow the use of a single shock (R0 2.0) to explore how the pandemic impacts upon the households and how, in general, they respond to compensate for the pandemic.

Household Results

The reductions in real GDP mask substantial differences in the welfare effects (Equivalent Variation – EV)[17] for the Representative Household Groups (RHG): Fig. 6 reports welfare changes for all households for the planting season shock at intensity R0 of 2.0. A clear pattern emerges for all RHGs: the EV measure inclusive of leisure (EV) is always more negative than the EV measure defined over the consumption of goods and services (G&S) only, excluding leisure. This demonstrates how the RHGs respond by reducing leisure to compensate for income lost during the pandemic.

[17] Equivalent Variations are estimated with the Slutsky approximation; the nested utility functions render the Hicksian measure intractable.

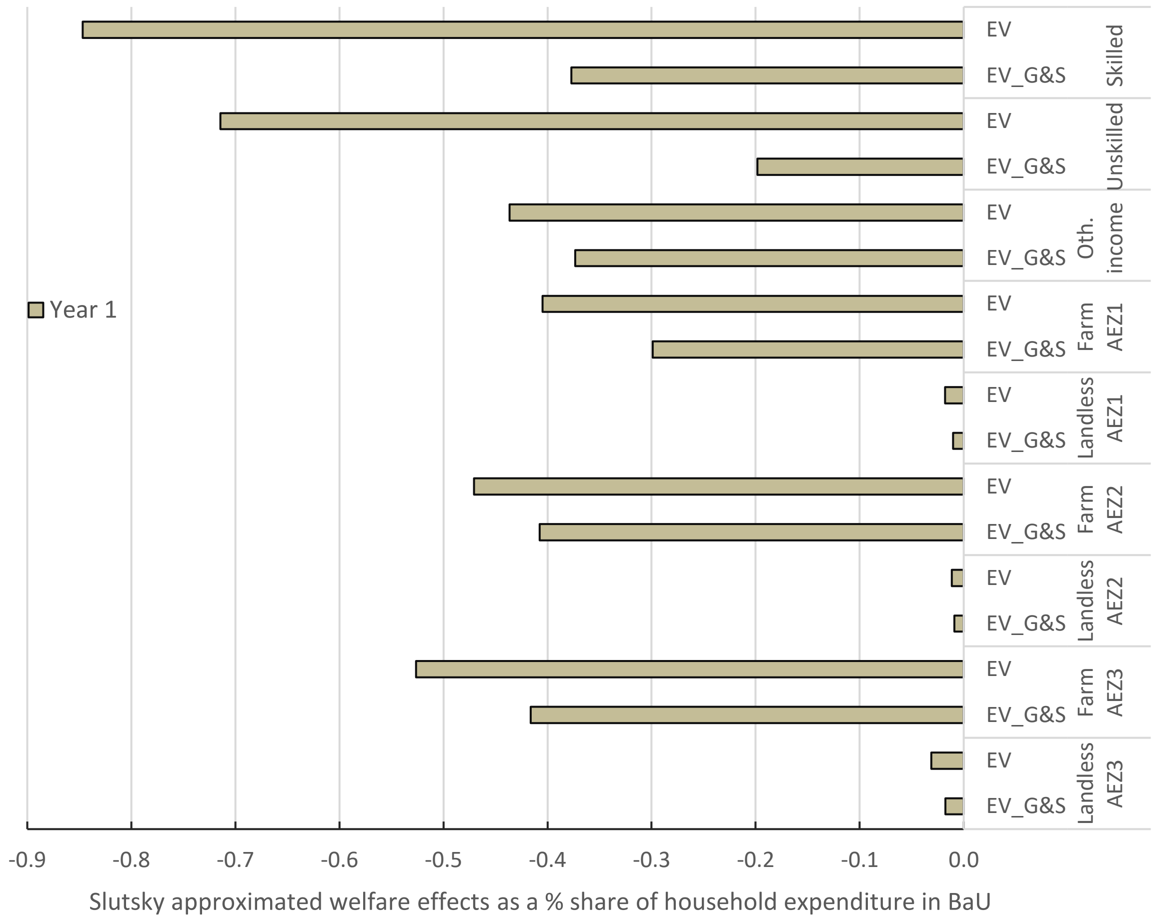

Fig. 6 - Household Welfare (R0 = 2.0; % change from BaU incl. leisure (EV), excl. leisure (G&S))

Source: Authors' calculations.

All RHGs reduce the consumption of leisure during the pandemic, Fig. 7; but the proportion changes vary markedly. In each agricultural zone, the landless households reduce their consumption of leisure less than the farm household in that region. Unskilled and other income households reduce leisure most, while skilled households reduce leisure by nearly as much as any farm household. The changes in the consumption of leisure depend on changes in the relative prices of leisure and aggregate consumption, a substitution effect, and changes in household incomes, an income effect.

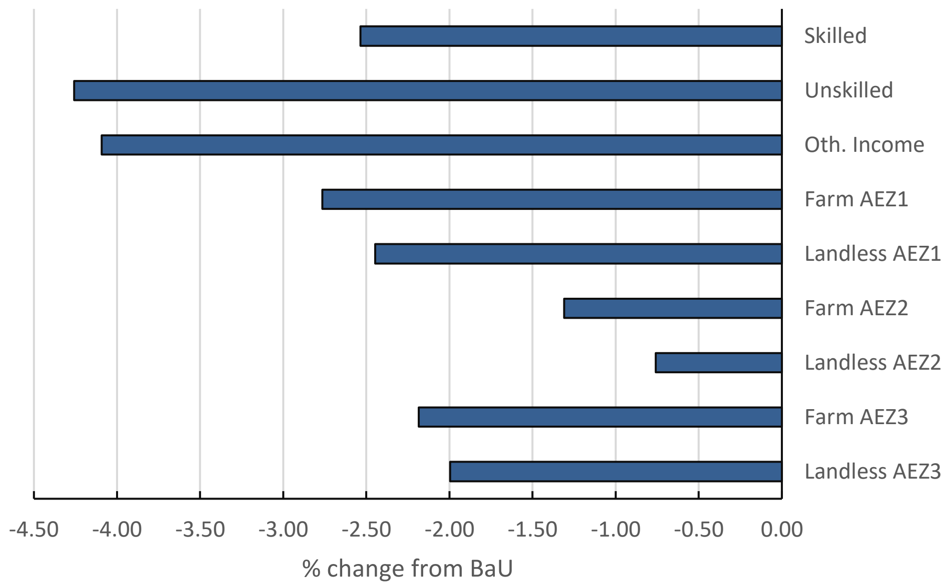

Fig. 7 - Consumption of leisure (R0 = 2, % change from BaU)
Source: Authors' calculations.

Factor incomes decline for all RHGs (Fig. 8), despite households reducing leisure and increasing working time. This is driven by the changes in factor endowment that, in combination with returns from incorporated business enterprises (enterprise income falls by 0.5% in the pandemic year), determine household incomes. The landless households get income primarily from wages. As seen in Fig. 8, the decline in agricultural labour is relatively small for each agroeconomic zone, less than a 1 percent decline relative to the BaU case. The farm households get income from wages and returns to land and returns to livestock. The latter two sources of income decline dramatically compared to the BaU. For example, the return to livestock in AEZ2 declines approximately 9 percent compared to the BaU. The loss in income from other sources explains the more dramatic reduction in consumption of leisure in farm households compared to landless households in any agroeconomic zone. Farm households adapt by moving more labour out of leisure.

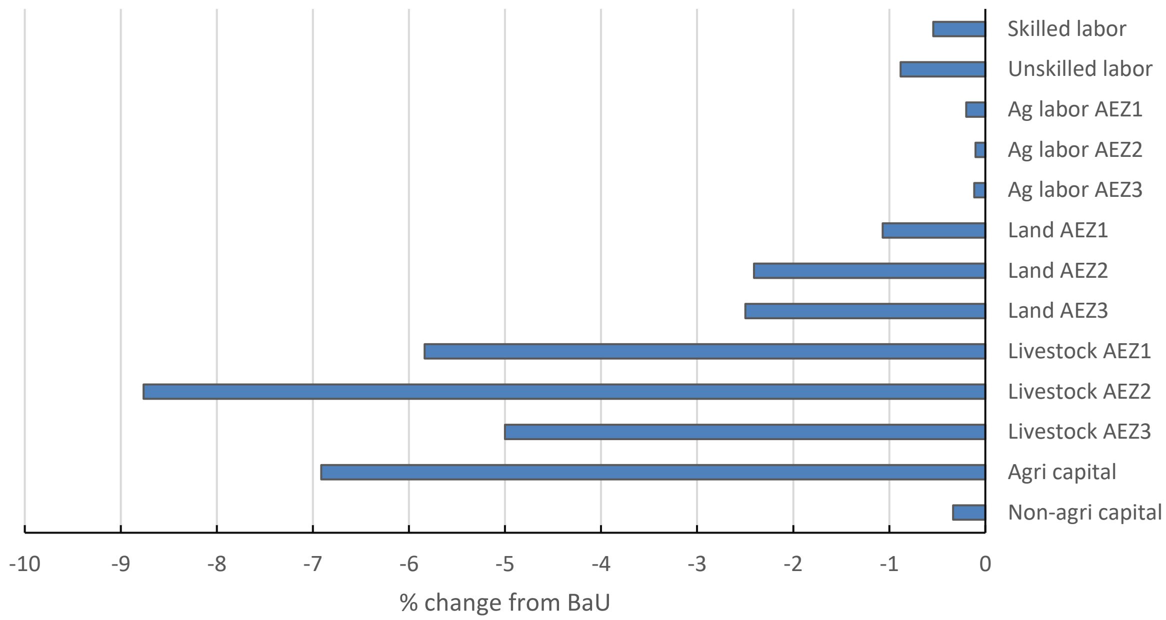

Fig. 8 - Factor Incomes (R0 = 2; % change from BaU)

Source: Authors' calculations.

Production and Consumption Results

While the general response by RHGs to the pandemic is broadly consistent across different magnitudes and seasons in which the pandemic occurs, there are differences in how production and consumption patterns change in response to the season the shock.

The timing of the pandemic affects labour adjustment across activities. Changes in labour allocation across production activities, including leisure, are reported in Fig. 9. Regardless of when the pandemic hits, less labour is allocated to leisure compared to the labour allocation in the BaU, with the biggest decline if the pandemic hits in the winter. Non-farm activities experience a bigger decline in labour if the pandemic occurs in the winter, the largest declines in textile weaving and community forestry. This is to be expected, as these activities are primarily performed during the winter season. If the pandemic occurs in the planting season, there are substantial reductions in labour in rice production (5.9 percent compared to the BaU) and cereals (4.4 percent compared to the BaU). In Bhutan, and in many other agrarian economies especially in Asia, the agricultural sector and thus also the rural labour market is dominated by the rice cropping calendar. The season in which paddy is transplanted is a critical month characterized by labour shortages and lowest consumption of leisure by households. Correspondingly, it is the season in which seasonal wages are most prone to spike, followed by the rice harvest season.

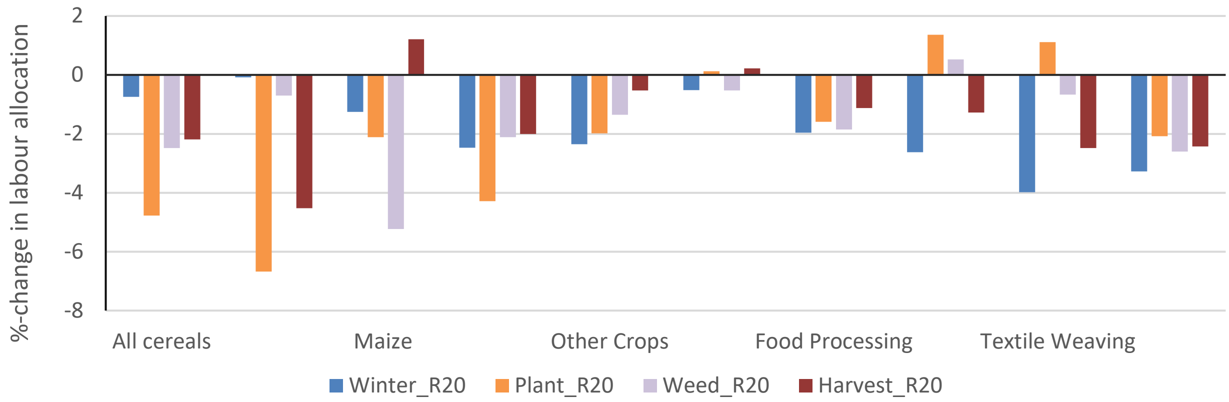

Fig. 9 - Changes in Labour Allocation (R0 = 2.0; % changes from BaU)
Source: Authors' calculations.

Changes in production patterns are reported in Fig. 10. There are dramatically different impacts if the pandemic occurs in the winter season versus the planting season. For example, cereal output declines almost 4.5% compared to the BaU if the pandemic occurs in the planting season, and declines only 0.5% compared to the BaU if the pandemic occurs in the winter season. Production declines the most in agriculture, crops and cereals when the pandemic hits in the planting season.

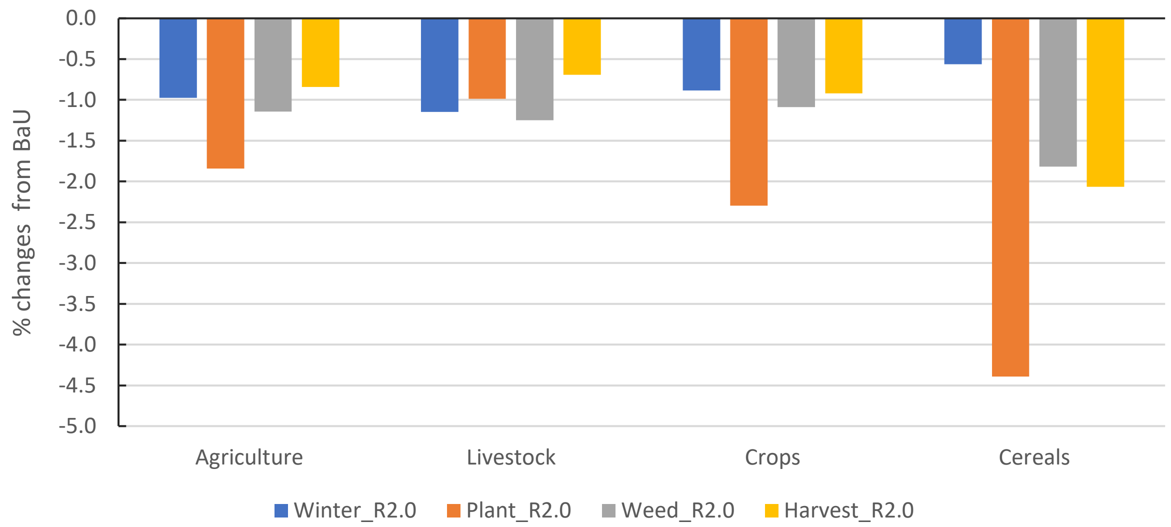

Fig. 10 - Changes in Production Patterns (R0 = 2.0; % changes from BaU)
Source: Authors' calculations.

Consumption patterns follow the same general pattern – the biggest declines in consumption of agriculture, crops and cereals occur if the pandemic occurs in the planting season (see Fig. 11).

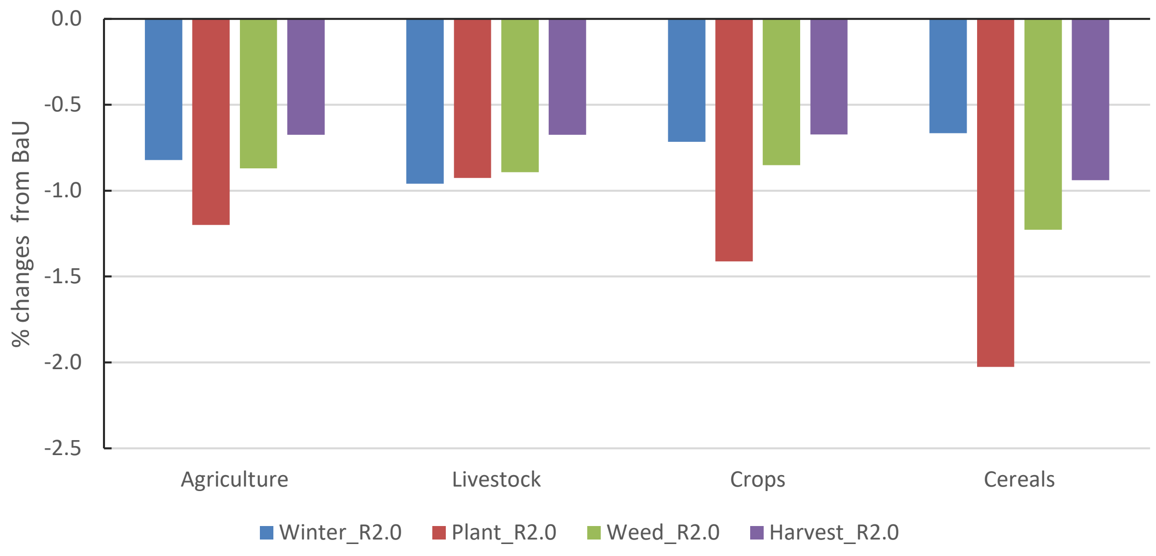

Fig. 11- Changes in Consumption Patterns (R0 = 2.0; % changes from BaU)

Source: Authors' calculations.

6. Concluding Comments

This study has explored some of the responses to a viral pandemic that may be realised in developing economies with a substantial proportion of peasant households. Even a pandemic that only produces in a single wave of infections, of relatively short duration, will inevitably reduce the level of economic activity. One result from this study, however, is that the downturn in economic activity may be less than expected due to mitigating responses by households and other agents. Another result is that the timing at which the pandemic reaches its peak in infections has great effect on the pattern of outcomes. Particularly pandemic events that coincide with peak agricultural seasons, as demonstrated in this analysis and as reported from studies on the Ebola outbreak in West Africa (La Fuente et al., 2019), result in more adverse impacts in terms of welfare and food security than shocks occurring during the agricultural lean seasons. Understanding these patterns may be of importance for the design of containment policies, as already a slight delay of an infection peak may substantially alter its impact on rural livelihoods.

The model used for the present analysis may be extended for future studies on the impact of pandemics. For instance, this study did not account for the fear of contagion among the population, which could result in a further decline in labour availability. This "fear factor" is difficult to quantify, but could be implemented by changing agents' preferences when trading off labour with leisure.

The estimated burden of the pandemic on households and society as a whole is likely to be at the lower bound. The assumption of an annual average reproductive number (R0) of 2 in the core scenario is conservative given much higher estimates in the literature (Liu et al., 2020). In addition to contagion fears, the study also does not account for secondary morbidity effects in the aftermath of the COVID-19 pandemic, which are still not sufficiently well known and understood. Moreover, this study has avoided discussion of the social and psychological implications of a pandemic. Premature deaths would be expected to be more traumatic than 'normal' deaths; a rise in premature death rates will therefore have adverse implications for wellbeing that this study cannot capture. Despite these caveats, it should also be noted that the study's main contribution is to investigate how pandemics affect the livelihoods of peasants and how this changes with different seasonal timings.

A critical presumption for this study is that peasant households are rational agents; they respond to changes to protect the wellbeing of household members. Despite the constraints imposed on peasant households by the seasonal fluctuations in the demand for labour in agricultural activities, there is an argument that peasant households can adjust their behaviour so that, at least partially, the negative effects of a pandemic are offset. A minor response is changes in the area cultivated. More substantially however they can increase the supply of labour to agricultural activities through reduction in time allocated to leisure and social reproduction, while they can, given warning, modify their patterns of production to reduce the demand for labour. Combining this with changes in the patterns of consumption they may be able keep proportionate reductions in wellbeing to less than the overall decline in economic activity.

There are reasons to be optimistic that the modelled adjustments, particularly by peasant households, may limit the extent of the damage to the economic wellbeing in a developing country. This study demonstrates that models that do not recognise the dual role of peasant households as productive activities and households, typically by presuming that peasant households operate in the same way as farmers in developed market economies, risks failing to recognise or understand how developing economies may respond to exogenous shocks such as pandemics.

There are areas of the analyses that will benefit from further development. In the case of a COVD-19 pandemic with the characteristics studied for these analyses an economic system is likely to return to its development path relatively quickly, albeit at a slight lower increase in

GDP. This reflects the fact that the nature of the pandemic avoids inter-generational effects, such as those associated with HIV. A COVID-19 style pandemic is likely to primarily increase mortality among the aged and while this will impact of the contributions of the elderly population to social reproduction it is likely to have limited impacts on demographic development. A substantial avenue for future research is the enriching of the development of the demographic structure of an economy, which would facilitate a richer evaluation of the development process, e.g., the acquisition of human capital, especially through female education, improvement in health status, e.g., reduction in infant mortality rates, and the evolution of dependence ratios among aging rural populations.

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Appendix

Appendix A – Days of hospitalization and ICU care and the estimated associated health care cost

COVID-19 Scenario (by reproductive number)	**Hospitalized (in bed-days)[a]**	**ICU (in days)[b]**	**Deaths**	**Treatment cost (million USD, 2012 prices)**	**% increase in government provided healthcare expenditure**
R0_1.5	13,260	4,192	2,562	3.78	10.8
R0_2.0	18,110	5,682	3,633	5.13	14.6
R0_2.5	20,283	6,352	4,108	5.73	16.4
R0_3.0	21,367	6,687	4,345	6.03	17.2

[a] Hospital health-care is assumed to cost 40 USD/bed-day
[b] Cost of ICU care is an average of cost estimates provided by Chatterjee S, Levin C, Laxminarayan R (2013) Unit Cost of Medical Services at Different Hospitals in India. PLoS ONE 8(7): e69728; and Ye et al. 2017 A Contemporary Assessment of Acute Mechanical Ventilation in Beijing: Description, Costs, and Outcomes https://dx.doi.org/10.1097%2FCCM.0000000000002360