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Water taxation and the double dividend hypothesis

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ABSTRACT

The double dividend hypothesis contends that tax policies which are aimed at protecting the environment can potentially yield other benefits for the economy. However, empirical evidence of the potential impacts of environmental taxation in developing countries is still limited. This may be partly due to the limited use of environmental tax policies in economic and environmental management in many of these countries. This paper seeks to contribute to the literature by exploring the impact of a water tax in a developing country context, with Uganda as a case study. Policy makers in Uganda are exploring ways of raising revenue by taxing environmental goods such as water. Whereas their primary focus is to raise revenue, this study is aimed at demonstrating how taxes on environmental goods can potentially yield other benefits beyond addressing a country's fiscal needs.

This study employs a computable general equilibrium model to shed light on the impact of a water tax policy when a tax is accompanied by a plough-back scheme of the same magnitude. We seek to establish whether a water tax policy that is accompanied by a revenue plough-back scheme can induce more growth, employment and industry output. Whatever the degree of regressivity resulting from the tax, it is possible to design a policy that benefits the economy. The policy was also checked for sustainability using a long-run water demand scenario. The results show that water demand remains more or less on the same trajectory and in fact, a higher level of dividends is realized.

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1. Introduction

A number of developing countries are experiencing both economic and environmental challenges. Similarly, the ability for these countries to pursue their development goals is often inhibited by a lack of resources. In order to realize their goals, several countries have employed a combination of measures which have instead altered their patterns of production and consumption, leading to substantial economic costs. This has necessitated the need to put into place measures that are capable of minimizing the costs of environmental regulation while achieving the desired economy-wide behavioural changes [1]. As a result, policy-makers are increasingly paying attention to the potential for incentive-based environmental regulation, i.e., through economic instruments. This is because this approach has the potential to generate additional government revenues – in the form of environmental tax receipts or the proceeds of auctioned emissions trading allowances, depending on the setting. This has led to the need to develop a closer link between environmental policy and tax policy [2]. This need is borne out of the recognition that on the one hand, the new government revenues may provide an opportunity for tax reform. On another hand, the availability of environmental taxes alters the constraints and costs of a prevailing tax policy. Specifically, the new taxes in addition to the existing ones may have a distortionary impact on the labour and capital markets.

In line with the developments in the economic and environmental policy arena, this paper analyses the impact of a tax on water in a developing country context with Uganda as a case study. During the 2013/14 fiscal year, the Ministry of Finance Planning and Economic Development (MFPED) proposed to apply a Value Added Tax on water. This tax measure was aimed at improving tax administration and generating revenue (see [3], page 44). Since the use of environmental tax instruments has not been a common policy measure in Uganda, the proposed intervention constitutes an interesting policy research issue and has therefore partly motivated this study. The study is aimed at investigating the benefits of environmental taxation beyond revenue generation. It is critical to undertake a study that assesses the impact of such an intervention from an economy-wide perspective. First, empirical evidence suggests that taxes on water resources can yield multiple benefits for the economy if implemented on the basis of equity (see e.g., [4–7]). However, the economy-wide impacts are most likely to vary depending on the context and cannot therefore be known apriori [8]. In this regard, policymakers need to understand these impacts in order to balance between the need to maximize the aggregate gains from these tax reforms and the rights to equitable sharing of the associated costs and benefits.

Second, water resources are increasingly becoming stressed in terms of quantity and quality across the globe. These strains are emanating from economic activity, demographic trends as well as severe changes in climate [9,10]. Projections indicate increased rainfall in high altitudes, and decreased rainfall in the low lying areas [11]. In addition, the increase in temperatures implies larger water demand and higher rates of evaporation, all of which combine to aggravate the problem. In Uganda, changes in climatic conditions are being experienced through increased rainfall volatility across seasons and rising temperatures [12]. These changes in climate have implications for future water resources availability with ramifications for poverty reduction, employment and food security [13].

Whereas the adverse effects of these climatic changes have become central to the debate on issues of long-term global, social and economic stability, the policy interventions in Uganda do not seem to be paying adequate attention to the long term impact of water resource availability from an economic point view. In fact, most of the existing studies on water resources in Uganda have focused mostly on hydrological aspects. This is despite the fact some of the country's economic challenges seem to be emanating from developments in the water sector (see [14], p.80). Amidst these challenges, Uganda has a substantial volume of water resources that could be utilized to mitigate the water related challenges in the economy. For instance, approximately 25 percent of country's surface area is covered by fresh water lakes and rivers [15]. However, critical sectors such as agriculture are still rainfall dependent. This is largely because the existing infrastructure to ensure optimal water use is limited. It is therefore critical that measures are put into place to harness resources that can be used to finance the development and expansion of water infrastructure. In this regard, a tax on water may therefore be one of the options.

The framework for analysing interventions which are aimed at efficient management of water resources through taxation has its foundations in Pigou [16]. Proponents of the use of environmental taxes argue that they are efficient instruments not only for protecting the environment but for generating other benefits for the economy. This is referred to as "double dividends" in the literature. This study therefore seeks to add to the existing empirical evidence by assessing the possibility of the existence of "double dividends" in the case of Uganda. The hypothesis asserts that economies stand to gain from the imposition of environmental taxes through environmental conservation, revenue generation, employment, poverty reduction, and overall economic growth via the "revenue plough-back" effects. Pearce [17] and Oates [18] argue that an environmental tax has the likelihood of conserving the environment as well as generate revenue that can be used to reduce other distortionary taxes on employment, investment and consumption. In fact Schöb [19] argues that tax related policy interventions are superior to other environmental policy instruments, such as command and control. In addition, there are other benefits that accrue if some of the realised tax revenue is invested in the provision of safe water. For example, the expansion of piped water infrastructure in Argentina during the 1990s reduced child mortality by 8 percent [20]. Other studies find that access to safe water reduces childhood exposure to pathogens in drinking water which may improve long-run health and educational outcomes [21].

This paper therefore seeks to investigate the impact of a tax on water on the Ugandan economy because there is the need to investigate whether environmental taxes can generate positive impacts in a developing country. Whereas related studies exist, these are limited and have been undertaken in different contexts and motivations. Some studies have been undertaken for developed or upper-middle income countries [see e.g., Van Heerden et al. [5]; Letsoalo et al. [6]; Blignaut et al. [7] for South Africa; Diao and Roe [22] for Morocco; Brouwer et al. [23], and Pulido-Velázquez et al. [24] for Europe]. Other studies have focused their investigation on a global scale (see [25,10]) in their analysis of the impact of tax on water on production, consumption, and international trade patterns]. Some focus on optimal water use in specific sectors (see [5,7,26]) while others have been carried out under situations of water scarcity (see [6,27–29]).

This study seeks to analyse the impact of an environmental tax first, with the view to assess its feasibility as a revenue generation tool. This is aimed at forming a basis for the future use of related policy instruments to generate revenue for the economy. Second, the study is aimed at investigating whether a tax is an effective instrument for environmental regulation to the extent that it can induce efficient water use. This is borne from the fact that while the country has sufficient water in the immediate term, projections show that it might not be the case in the long term (see [30]). As water becomes scarce, interventions are needed to economize on its use. In most developing countries, the mechanisms for efficient utilization of water are largely absent. These range from small scale and obsolete irrigation infrastructure to the low levels of water charges. These do not encourage efficient water use [31,10]. It is therefore argued that a tax would increase the price of water which in turn, would lead to the adoption of efficient ways of utilizing it (see e.g., [32]). Besides addressing the issues of distortionary taxes, the realized revenue would be used to meet the country's fiscal needs which among others, would allow for investment in developing the country's water sector infrastructure. Currently, the sector's infrastructural needs are financed from central government grants and external sources.

Third, some studies use partial equilibrium models in order to assess the impact of water resource policies on the economy (see [33,34,36]). These do not provide adequate analysis of issues whose impacts are bound to be economy-wide [37]. Some studies use Input – Output models to analyze the impact of water resource policies on the economy [38–42]. Whereas I – O models provide for a general equilibrium environment in which one can trace the multiplier effects in order to perform distributional impact analysis, these models lack the standard statistical properties (see [43–45]). In addition, the linearity assumption of basic input – output models and the absence of market and price considerations make them to be less favourable. Some studies assess the impact of policies using virtual water [46]. Others use global models to assess the impact water resource policies on the economy (see [31,47,48,25]). Given the aggregation and assumptions which are made when developing such models, their accuracy may be questionable. Those that use CGE models mostly focus on the impact of water resource policies on specific sectors of the economy [49,22,5] or regions of the economy in some cases (see e.g., [50,51]).

In this paper, we use a CGE model that has been specially developed using Ugandan data to analyze the impact of a tax on water on the Ugandan economy. A specially developed computable general equilibrium model is used to investigate the economy-wide feedbacks and the welfare implications of the proposed tax intervention. The rest of the paper is organized as follows: Section 2 provides an over view of the developments in water sector in Uganda and the associated social-economic trends, Section 3 highlights the key issues in the literature with respect to the double dividend hypothesis, while the analytical framework and data issues are discussed in Section 4. Section 5 presents the setting of our policy scenario and model closure conditions while the results and discussion are presented in Section 6. Section 7 presents the conclusion and emerging issues arising from the study.

2. The water sector and Uganda's economy

Discussions of water issues regularly highlight the importance of water for food security and public health as well as its contribution to the transformation of agro-based developing economies. Water related policies have therefore become central on the agenda of the international community [52]. For instance, among the targets for the Millennium Development Goals is MDG 7 which seeks to ensure environmental sustainability [53]. The target is to ensure "reduction by half, the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015". Haller et al. [54] in their study of the economic returns on investments in water supply and sanitation indicate that every US$1 spent on water supply and sanitation services yields an economic return of approximately 5 – 46US$, with the highest returns going to the least-developed areas. Much of this additional income accrues from the time saved by having reliable water supply close to the household [55]. Studies show that inadequate water supply is a contributor to many deaths in children under 5 years [56,57].

Studies also show that investment in water can induce a reduction in poverty [58]. It can therefore be argued that adequate water and sanitation is an essential prerequisite for economic development. Poor countries with access to improved water have been cited to experience an average annual growth of 3.7 percent. On the other hand, countries with the same per capita income but without such access have an annual growth rate of only 0.1 percent [59]. In Uganda, water is central to supporting production across different sectors of the economy [30]. In developing countries, constraints to water supply, whether for productive or domestic uses, are shown to have direct and adverse impacts on livelihoods [60,55]. This relationship between water resources and the economy is demonstrated by the Ministry of Water and Environment in an analysis of the effects of droughts on the agricultural sector [15]. In periods of drought, all crops in the nine distinct farming systems in the country experience a moisture deficit ranging from 128 to 251 m^3 for perennial crops and 128–242 m^3 for non-perennial crops. Hence, any sustained period of drought can have adverse effects on the economy.

Several studies urge the need for investment in low-cost water harvesting techniques, irrigation, and clean water provision as a means of increasing food production and reducing the infectious disease burden [4,61]. In Sub-Saharan Africa and south Asia for instance, access to a small amount of irrigated land has transformed food security for the highly vulnerable households [62]. In Uganda, consequences of the absence of low cost water harvesting techniques and irrigation are demonstrated by an assessment by the Office of the Prime Minister (OPM) [63] which cites how rainfall deficits severely affect food security in the country. The decline in agricultural output presents a knock-on effect on food prices leading to further macroeconomic instability. The study by the OPM [63] estimated that the value of damage and losses caused by the rainfall deficit was approximately US$ 1.2 billion equivalent to 7.5 percent of GDP in 2010. Fig. 1 highlights the losses which accrued from this shock. The adverse effects of the shock were highly felt in the productive sectors of the economy. A breakdown of the sectoral effects shows that the livestock sub-sector lost UGX 1.1 trillion while the production of food and cash crops registered UGX 1.0 trillion in damages and losses. There were losses in agro-industry of UGX 278.0 billion; commerce lost sales of approximately UGX 169.9 billion; while electricity production losses amounted to UGX 106.3 billion. In addition, there were effects on other sectors such as sanitation, health care provision and nutrition assistance, education as well as food aid to the severely affected regions.

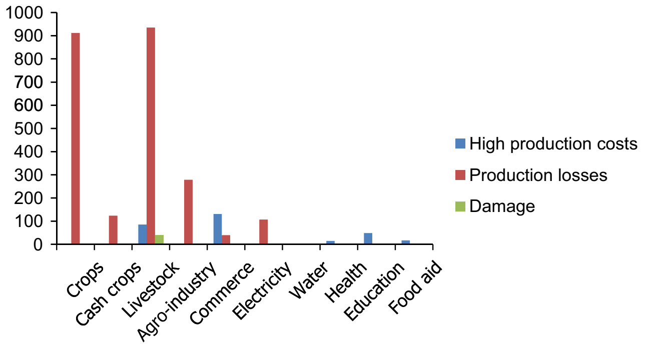

Fig. 1. Sectoral damages and losses from the 2010 – 2011 rainfall deficit (UGX Billions). .
Source: [63]

Amidst these water related challenges, the country is endowed with a substantial amount of fresh water from the different sources which can be utilized to address some of the challenges. The total volume of renewable resources is estimated at approximately 43.3 billion m^3 [15]. With regard to surface water, there are eight major catchment areas which drain into other water bodies within and outside the country. According to DWRM [15], the estimated renewable groundwater resources exceed current projections of demand for domestic water supply by a substantial margin. This is with respect to areas which are not served under the piped water distribution network. Projections indicate that the sustainable utilization rate for the year 2030 is below 15 percent for most areas [15]. However, these water resources experience both seasonal and spatial variability, a situation which is further being exacerbated by the volatile changes in temperature and precipitation. In fact, Carter and Parker [64] note that groundwater resources are dependent on rainfall for replenishment and this makes them to be susceptible to climatic variability. Hence uncontrolled abstraction of water can present a danger of causing a fall in water levels and exhaustion of resources [65].

Whereas Uganda receives a mean annual rainfall of 1200 m^3, the positive effects of this rainfall are eroded by the high rates of potential evaporation which is approximately 75 percent within the range of 1350–1750 m^3. This implies that in the absence of sustained rainfall, the ground water recharge capacity in most areas of the country is greatly affected. This is exacerbated by increasing temperature which adversely affects regions where rainfall intensity is less than potential evapo-transpiration. Worse still, effective utilization of the existing water resources is curtailed by a mismatch between the location of the water resources and the regions where demand is high, notably the arid and semi-arid areas of the country [30]. MacDonald et al. [66] suggest that areas which, in addition to prolonged droughts and sparse populations have no reliable water supply, development of groundwater through natural reservoirs is the only realistic option for significantly improving water coverage. Once such instances of lop-sided availability of water resources are put into account, Kemp et al. [67] argue that statistics on national water resources prove not to be a good indicator of water scarcity. Their view is that it is critical to have water resources (usually groundwater) close to the point of need. This calls for the need to develop the necessary infrastructure. MacDonald and Calow [68] conclude that inadequate attention to the variability in the nature and occurrence of water resources is a key reason for having expensive and unreliable water supply. This implies that in the absence of the necessary infrastructure, such regions continue to suffer.

In Uganda, current per capita water consumption is still low. However, it is projected to rise gradually from the current 21 m^3 to approximately 30 m^3 per capita per annum by 2035. This implies that policies and infrastructure have to be put into place to ensure efficient utilization of water resources. This is related to the fact that water sources across the globe are under threat from pollution through intensive agriculture, industry, and poor sanitation. The ramifications for developing economies are that since expensive water treatment is not affordable, the only option is for people to use contaminated water [55]. Table 1 highlights Uganda's water demand projections by sector.

Table 1
Water demand estimates and projections (millions m^3).
Source: [30].

Sector	2009	2015	2020	2035
Domestic: NWSC	56	85	116	284
Domestic: small towns	24	35	47	111
Domestic: rural	127	210	306	588
Livestock	107	151	164	211
Crops	335	489	452	676
Fisheries	52	105	157	210
Rural industries	5	19	23	33
Total water demand	**707**	**994**	**1,266**	**2,113**
Available water percapita (m^3)	2,171	1,740	1,480	896

Note: NWSC stands for National Water and Sewerage Corporation. This is a Government parastatal charged with the supply of commercial water in the country.

The role of water as a vital economic resource is not in doubt. However the debate is on the best policy to ensure its efficient use. There are two schools of thought on the economic value of water [69]. One school argues that water should be allocated to its best uses by being priced at its economic value. In addition, it should be allocated through competitive markets. Using the market theory, the value of a commodity is the maximum amount which users are willing to pay for it such that in equilibrium, the marginal cost and marginal benefit are equal [70,69]. Another school of thought maintains that water should not be left to market forces because it is a basic human need. However, the current challenges faced by water resources underscore the need to ensure their efficient utilization. In this regard, the current study is motivated by the challenges faced by water resources to argue that water should be utilised in a framework that accounts for its economic value, while still ensuring that it is being equitably accessed.

2.1. *Tariff levels and pricing policy*

Water pricing policies are important instruments to achieve national and regional goals. In this regard, users should pay a fair price for water in order to reflect its value to society as a scarce resource. For the case of Uganda, the legal framework for the provision of commercially distributed water provides for such measures. According to Statutory Instrument 2002 no. 23,

> "*NWSC Water and Sewerage rates shall be subject to annual indexation against the domestic price index, exchange rate, foreign price index and electricity tariff so as to maintain real value of the tariff*".

However, the tariff structure in the country has largely been based on affordability and uniformity across the country while ensuring cost recovery [71]. As a consequence, the tariff levels and structure have not been adequate for system expansion as they only cover operational and maintenance costs. Major investments in the sector's infrastructural improvement and extension are currently being financed by direct transfers from government and support from development partners. This trend is likely to continue until revenue mobilization reforms are undertaken within the water sector in order to generate revenue and ensure efficient water resource utilization. The realization of cost recovery in terms of operation and maintenance, depreciation as well as investment would require an increase in tariffs. Table 2 shows the evolution of the tariff structure for commercially supplied water in Uganda.

Due to the rising operational costs, the NWSC increased the tariff rates based on the policy of tariff indexation in response to a 69 percent increase in the electricity tariffs in 2012. From Table 2, it is evident that there was a significant increase in the tariff level compared to the previous years. In addition, the NWSC uses a rising block tariff structure for commercial consumers to ensure efficient water use. However, the tariff level still needs adjustment in order to ensure efficient water use and revenue generation for infrastructural expansion. Structurally, the tariff is higher for the commercial consumers and lower for the domestic consumers with the lowest being for bulk sale at stand taps.

Table 2
National water and sewerage corporation tariff structure (UGX/m^3).
Source: [72].

Customer category	Old Tariff 2004/05	Adjustment 2005/06	Adjustment FY2006/ 07	Adjustment 2007/08	Adjustment 2012 to date
Public standpipe	521	568	688	784	1,236
Domestic	806	879	1,064	1,213	1,912
Institutions/ Government	993	1,082	1,310	1,493	2,353
Commercial <500 m^3/m	1,379	1,4622	1,716	1,931	2,887
Commercial 500–1500 m^3/m	1,421	1,462	1,716	1,931	2,887
Commercial >1500 m^3/m	1,324	1,324	1,496	1,601	2,307

However the poorer households which inevitably use these stand taps generally end up paying more for the water collected due to their high operational costs.

2.2. Institutional framework for water resources management in Uganda

The management of water resources is under the Ministry of Water and Environment (MWE). This function is enshrined in the Water Act (Cap 152) of the Constitution of the Republic of Uganda [30]. The MWE is charged with the planning and coordination of all sector activities with the overall mission of “promoting and ensuring the rational and sustainable utilization, development and effective management of water and environmental resources for the socio-economic development of the country”. The MWE is therefore tasked with setting national policies and standards, managing and regulating water resources and determining priorities for water development and management. It also monitors and evaluates sector development programmes to keep track of their performance, efficiency and effectiveness in service delivery [30]. The Ministry has the following directorates: Directorate of Water Resources Management, Directorate of Water Development (DWD) and the Directorate of Environmental Affairs (DEA). In addition, there are agencies such as the NWSC whose role is to supply commercial water. The agency derives its legal mandate from Decree no. 34 of 1972 and later from the National Water and Sewerage Act enshrined in the (1995) Constitution of Uganda. This agency is charged with improving water and sanitation services in the country on a commercially viable basis [73]. Accordingly:

> *Using the New Economic Order Model* (*NEO*) *which was introduced in 2011 as a planning tool premised on the principle of demand and supply of water*, *the agency seeks to achieve equilibrium between effective demand for our services by ensuring that the customer is adequately and efficiently served*, *while ensuring optimization of resources*.

It is clear that the NWSC's model is geared towards ensuring efficiency in the commercial provision of water. In fact, the approach is in line with the existing evidence on the estimated potential welfare gains from improvements in the quality of water service such as reducing variability or interruptions in the water delivery schedule [74]. This has been established to be the case for both developing [75] and industrialized countries [76]. It is therefore vital that one of the interventions of the NWSC should be to ensure that water pricing is based on supply cost recovery and full economic cost [6].

3. Literature review

Measures to introduce environmental taxes may face opposition as these taxes could potentially have adverse affects on employment and the competitiveness of national industries. However, the rationale behind environmental taxation is to increase welfare. The benefits may be hard to quantify and are often realized over a long period. It is against this background that the double dividend theory has become central to investigating the impact of environmental taxes on the economy. According to this theory, the revenues from the realized taxes can be used to lower other (distortionary) taxes. In that case, an environmental tax may not result in an extra tax burden following its imposition. In fact, a tax my yield positive effects on output and employment as a results of lowering other taxes. In this section, we highlight the existing literature on the double dividend hypothesis. The review is not exhaustive as it is only aimed at indicating the nature of the debate surrounding the double dividend hypothesis (see [77,78,80,79,10,19,81,82]) among others, for extensive reviews on the subject. In addition, it is aimed at providing a context for this paper. In the literature, some authors suggest that measures to address changes in the environment should be designed to use policy instruments that raise revenues. This is because the resulting revenues can be used to generate other benefits for the economy. Since Pigou [16], it has been widely accepted that environmental taxes are efficient instruments for environmental protection. In addition, they are found to be superior to other policy instruments like command and control.

The arguments in favour of taxes on environmental goods have their foundations in the double dividend theory. According to the theory, revenue generated from the imposition of environmental taxes can be used to lower other would be distortionary taxes. In so doing, the economic cost of the environmental tax is lowered thereby resulting into benefits for the economy (see [83–85,64,5,7,23,10,87,82]) among others. The major implication of the double-dividend theory is that if there is consensus about an environmental target, revenue-raising instruments are preferred to other policy instruments which, although cost-efficient in regulating the environment, do not raise public revenues [19]. Realization of the double dividend is in terms of the environment (first dividend) and the economy (second dividend) which are envisaged to improve following the imposition of the tax [6]. Goulder [78] develops two versions of the double dividend hypothesis: the strong and the weak form of the double dividend. The weak form requires a revenue-neutral environmental tax reform to plough-back the additional revenues in order to reduce the economic costs of the tax compared to the case where those revenues are ploughed-back as a lump-sum. On the other hand, the strong form version requires that environmental tax reform to not only yield environmental gains but also non-environmental welfare [88]. Economic analysis demonstrates the potential benefits of ploughing back revenue from an environmental tax. Specifically, such a tax can be used to offset other taxes thereby reducing the potential cost of the policy. Under certain circumstances, it can boost economic welfare [78 in 88]. However, Zhou and Segerson [87] demonstrate that depending on the size of the tax base, environmental taxes may be efficient instruments for improving environmental quality, but not necessarily a better way to raise revenue.

Several studies use different approaches to check for the existence of the double dividend hypothesis in many different contexts. Bovenberg and De Mooij [89] use a simple one factor model which assumes competitive markets and find that environmental taxes exacerbate, rather than alleviate the pre-existing tax distortions. Fullerton and Metcalf [90] and Goulder et al. [91] show that increasing a narrow-based green tax and reducing a broad-based tax say on labour income would be distortionary. This implies that the revenue-plough-back effect may not fully offset the negative effect of the environmental tax on employment. This would be the case even when the revenue is used to reduce the tax rate on labour income. The literature highlights the fact that whereas a strong double dividend is possible, it not may not always be guaranteed. In fact, it depends on a number of factors which among others include the existing tax rates; elasticities as well as the level of inefficiency of the tax system (see [78,5,93,87,82]). In the case of an environmental tax that targets water as a factor of production, substitution elasticities between factors are critical. The fixed factor, capital should be a poor substitute for the water, while labour should be a good substitute. With an elastic supply of capital, the converse is true (see [94]). This efficiency gain has to be large enough in order to offset the negative impacts that are inherent in environmental taxes. The broader is the tax base, the lower is the distortion. Goulder [97] asserts that environmental taxes are usually narrow because they are meant to change specific behaviour.

Goulder [78] and Bovenberg and Goulder [94] use a general equilibrium model and fail to find evidence of a double dividend. In all their scenarios the environmental tax is found to be more distortionary than the substitute taxes and they attribute this finding to the relative narrowness of the environmental tax. For instance, Goulder [78] finds that the economic cost of environmental taxes would be in excess of 35 percent if the revenues are ploughed-back across the board rather than in a targeted manner to reduce other distortionary taxes. On the other hand, Jorgenson and Wilcoxen [96] do find a double dividend under certain conditions. Irrespective of the end result, the costs or benefits of the tax reform were found to vary with the scenario chosen. However, they were in line with Goulder's [97] expectations. That is, the lower are the costs, the larger are the differences in Marginal Excess Burden (MEB) and the more the tax burden was shifted from the overtaxed to the under-taxed factor.[1] Zhou and Segerson [87] utilize the framework by Bovenberg and de Mooij [89] to assess the viability of using environmental taxes to finance budget deficits in the US state of Connecticut. They find that due to the narrowness of the tax base, environmental taxes have limited potential to raise revenue to finance the fiscal deficits and/or reduce other distortionary taxes. Nonetheless, they note that such taxes can still generate significant gains for the economy if they lead to significant improvements in environmental quality.

The analysis of the double dividend hypothesis besides revenue mobilization involves the redistribution of income in the economy. Worth noting is the fact that the process results in the deviation of the tax mechanism from its optimal level.[2] Therefore, the distributive impacts of environmental tax reform need to be studied in much detail. There are studies which have looked at the distributive component of environmental taxation (see [6,98,5,7,10,99]). The findings suggest that the distributional impact of the tax depends on the specific form of the tax reform and how it is implemented. The suggestion of shifting the tax burden to the unemployed or those working in the informal sector to increase employment as is in Bovenberg and Vander Ploeg [100] has the potential to adversely affect income for the lowest income groups.

From the existing literature, it is clear that the double dividend hypothesis has been analyzed using different methodologies, assumptions, and measures. It is therefore not surprising that these studies yield mixed results. For instance, studies in the developed countries tend to find a positive second dividend when employment is used as a benchmark and modest positive or negative effects on output (see e.g., [101,79,80,102–104]). However Schöb [19] fails to find evidence of the strong form of the hypothesis in his study of the United Kingdom. Empirical studies in the U.S have found that when revenue from environmental taxes is used to reduce pre-existing taxes, the gross cost of the tax system increases, i.e., the strong form of the double dividend hypothesis does not hold [87]. Goulder [105] finds that welfare is reduced by 0.48 percent when the environmental tax is used to reduce the corporate income tax and by 0.53 percent when used to reduce the personal income tax. Furthermore, Goulder [78] reviewed some empirical studies based on different models and found that a tax swap resulted in a welfare loss for most models except the Jorgenson – Wilcoxen model (see [87]).

For the developing countries, some studies find evidence of the hypothesis in its strong form, but add a caveat that the design and implementation of such interventions is critical. For instance, Van Heerden et al. [5] use a CGE model to investigate of the plausibility of achieving a double dividend through a tax on water and energy and plough-back the revenue back into the economy. They find that it is possible for such interventions to yield double dividends. Other studies with closely similar findings include Decaluwé et al. [49]; Diao and Roe [22]; Bluffstone [104]; Letsoalo et al. [6] and Blignaut et al. [7]. In fact Sartzetakis and Tsigaris [107] note that environmental tax reform may reduce involuntary unemployment. With regard to equity, such reforms can adversely affect the income distribution, thereby reducing the possibility of achieving a second dividend.

From the literature, it can be concluded that achieving a double dividend from an environmental tax is possible but it is not obvious. The initial conditions in terms of the existing taxes, possible distortions in the labour market, together with the specific nature of the tax intervention are key determinants of the outcome of any such policy measure. Therefore, the design of the tax intervention should clearly be well thought out, with attention being paid to the pre-existing distortions [6]. In fact, interventions that are designed to yield multiple benefits i.e., additional dividends (say poverty

[1] See Goulder [97] for a thorough exposition on the adjustment mechanism.
[2] In the absence of externalities it would be optimal to have a lump sum tax.

reduction) require more detail with respect to their policy design. Spratt [108] in a scoping study of environment taxation in developing countries concludes that limits to the effectiveness of environmental taxes become more severe as the number of policy goals increase. He asserts that achieving "double dividends" may be hard and triple dividends even much harder.

4. Methodology

This study employs the Uganda Applied General Equilibrium (UgAGE) model to evaluate the economy-wide impact of potential water tax scenarios in Uganda. The theoretical structure of UgAGE is based on the ORANI-G model documented in Horridge [109] with various add-ins to facilitate the detailed modelling of water accounts in the country. In this version of UgAGE, we use an aggregated 13-sector database. The model is implemented in GEMPACK and solved using Euler's multi-step solution technique.

Applied or computable general equilibrium models provide industry-level disaggregation in a quantitative description of the whole economy and typically postulate neo-classical production functions and price-responsive demand functions, linked around an input-output matrix in a general equilibrium model that endogenously determines prices and quantities. As required by GEMPACK, an initial levels solution of the model is represented by the base year data. The theory of the model is then, essentially, a set of equations that describe how the values in the model's database move through time and move in response to any given policy shock. For any given exogenous policy shock, the results produced by the model represent changes or percentage changes away from an unperturbed projection of the economy and its structure, represented by the base year data.

Following the ORANI-style of implementing a CGE model, the general equilibrium core of UgAGE is made up of a linearized system of equations describing the theory underlying the behaviour of participants in the economy. It contains equations describing, amongst others: the nature of markets; intermediate demands for inputs to be used in the production of commodities; final demands for goods and services by households; demands for inputs to capital creation and the determination of investment; government demands for commodities; and foreign demand for exported goods.

The specifications in UgAGE recognize each industry as producing one or more commodities, using as inputs combinations of domestic and imported commodities, different types of labour, capital and land. The multi-input, multi-output production specification is kept manageable by a series of separability assumptions. This nested production structure reduces the number of estimated parameters required by the model. Optimising equations determining the commodity composition of industry output are derived subject to a CET function, while functions determining industry inputs are determined by a series of nests. At the top level, intermediate commodity composites and a primary-factor composite are combined using a Leontief or fixed-proportions production function. Consequently, they are all demanded in direct proportion to industry output or activity. Each commodity composite is a CES function of a domestic good and its imported equivalent. This incorporates Armington's assumption of imperfect substitutability for goods by place of production [110]. The primary-factor composite is a CES aggregate of composite labour, capital and, in the case of primary sector industries, land. Composite labour demand is itself a CES aggregate of the different types of labour distinguished in the model's database. In UgAGE, all industries share this common production structure, but input proportions and behavioural parameters vary between industries based on available base year data and econometric estimates, respectively. In this regard, the model parameters used in our analysis are derived from the IFPRI model for Uganda (see [111]), in addition to other relevant studies in the literature (see [112–115]) and informed by the author's knowledge of the Ugandan economy. Those sets of parameters include: (1) The Armington elasticity between domestic and imported commodities; (2) Export elasticities; (3) Elasticity of substitution among labour types (or skills); (4) Elasticity of substitution among primary factors; (5) CET transformation for industries with multiple commodities; (6) Expenditure elasticity for the LES household demand system; (7) The Frisch parameter (elasticity of marginal utility of income) and (8) The Armington elasticity for investment.

The demand and supply equations in UgAGE are derived from the solutions to the optimisation problems which are assumed to underlie the behaviour of private sector agents in conventional neo-classical microeconomics. Each industry minimises cost subject to given input prices and a constant returns to scale production function. Households maximise a Klein – Rubin utility function subject to their budget constraint. Units of new industry-specific capital are constructed as cost-minimising combinations of domestic and imported commodities. The export demand for any locally produced commodity is inversely related to its foreign-currency price. Government consumption, typically set exogenously or linked to changes in household consumption, and the details of direct and indirect taxation are also recognised in the model. Zero pure profits are assumed for all industries.

The model's database is based on the 2009 Social Accounting Matrix (SAM) for Uganda published by the Uganda Bureau of Statistics (UBOS). In the SAM, households are categorized into 4 regional groups by rural-urban and by income quintiles. In all, there are 39 industries and commodities. However, these were aggregated into 13 sectors to facilitate our analysis. This is in addition to splitting electricity and water into two industries. Water data [116,117] are drawn from the relevant departments under the Ministry of Water and Environment in order to create a vector of taxable water for each industry in the SAM as well as a vector of extra water charges that may be charged on volumes of water. All taxable water is derived from ground and surface water data.

Next, we add a water revenue equation into the UgAGE model to enable us to calculate changes in total revenue raised and changes in water demand. It is derived from the identity that total revenue raised R is equal to the tax rate T per volume times the quantity of water X. That is

$$R = TX \tag{1}$$

All model equations are expressed in percentage change form. The model is linearized in order to allow for solving. From Eq. (1), the change in revenue dR is approximately equal to the tax rate T times the change in the base dX plus the base Xtimes the change in the rate dT. Formally:

$$dR = TdX + XdT = TXx/100 + XdT = Rx/100 + XdT \tag{2}$$

with x being the percentage change in XIf $x$is the percentage change in X,then we know that $x = 100*dX/X$,such that $dX = xX/100$.Eq. (2) is used in our model to calculate the changes in revenue received from charges on water consumption by all industries. The changes in the tax rates are exogenous. In addition, they are shocked according to various scenarios outlined in Section 5. All the other variables are either entered into or they are computed by the model. Note that the variable x is the percentage change in water consumption by industries and it is endogenous. Put differently, x is computed by the model. We expect that an additional charge on water will lead to a decrease in water consumption. Total revenue from the extra water charges will be added to total government revenue.

5. Policy scenarios

In this section, we employ different taxation and plough-back scenarios to assess the distributional effects of a water tax. This involves levying a tax and establishing the appropriate channels through which the realized tax revenue can be utilized in order to yield dividends for the economy. The simulation scenarios employed are in line with the policies of the Ministry of Finance Planning and Economic Development of revenue mobilization. Similarly, they are related to the vision of the Ministry of Water and Environment and the water distribution agency (NWSC) of improving water and sanitation services in the country on a commercially viable basis. Whereas the critical policy issues include revenue generation and provision of water at market rates we use simulation scenarios which reflect the fact that issues of access and affordability are equally important.[3] The charges for some sectors of the economy particularly the households majority of which are poor, should not be at a level where they are left without access to safe water [108].

[3] See e.g., Gowlland-Gualtieri [119] for a contextualized exposition of how issues of sustainability and equity in the provision of water are implemented in South Africa.

Cognizant of the issues of affordability and access, the following scenarios were simulated using the UgAGE model. A tax of UGX 500 (US$20cents per m^3) on water used by the following industries: (i) Mining; (ii) Manufacturing; (iii) Construction; (iv) Agriculture; (v) Business; (vi) Hotels and restaurants; (vii) Other services.[4] The choice of sectors was informed by their ability to pay as well as the degree of water use in their production activities. Industries with less water use in their activities were left out. In terms of plough-back, three simulations were performed: (a) a decrease in production taxes on capital and labour; (b) a decrease in sales taxes, and a decrease in taxes on exports.[5] The choice of the plough-back schemes was informed by the fact that the reduction in the level of taxation to factors of production would induce economic activity via production while a sales tax break would drive economic activity via consumption. The third policy option was chosen because Uganda is a small open economy and taxes on water could be harmful on the traded sectors.

5.1. *Policy variables*

Four variables of interest are analyzed in the model. These include changes in: (a) water use; (b) GDP; (c) employment; (d) industry output. The variables are expressed in "per unit of government revenue" so that the different policy scenarios are comparable. These variables presented in the next section as changes in water consumption per billion shillings in government revenue; Percentage change in real GDP per billion shillings of revenue collected or ploughed-back; Percentage change in aggregate employment per billion shillings of revenue collected or ploughed-back; and changes in industry output.

5.2. *Model closure*

In order to analyze the impact of a water tax on water use and the economy as a whole, the effectiveness of such a policy measure has to be assessed on how sustainable it would be with respect to the use of water resources. In this regard, the model closure rules have been set to account for policy sustainability using the long-run time horizon.[6] Results from the policy measures for both long-run and short-run closures are presented in Section 6. Under the short run closure conditions, capital stock in each sector is exogenous, while the rates of return on capital, aggregate employment and trade balance are endogenous. The trade balance is set to be endogenous because it is possible for the economy to run a deficit on the external sector in the short run. In addition, aggregate investment, the composites of GDP from the expenditure side (private and public consumption), real wage rate, all technological change variables and all tax rates inventories are exogenous. Furthermore, the reader is invited to note that the both closure conditions set all technological change variables and all tax rates and inventories are exogenous in both closures.

Under the long run closure rules, the income side of GDP is set such that labour supply (aggregate employment) is exogenous at its full employment level (i.e., not to be driven by policy but by demographic factors). This is in line with the fixed non-accelerating inflation rate of unemployment (NAIRU) in the long-run [121]. The real wage rates are endogenous as they are considered to be flexible in the long-run since wage contracts are periodically renegotiated. By absorbing any demand-side pressure via changes in real wages, the labour market is allowed to clear. Similarly, capital stock is endogenous in order to reflect changes in net investment in the long-run while the rate of return on capital is exogenous. This is because the factors which influence long run rates of return such as interest rates and risk premiums are relatively stable and unlikely to be affected by policy interventions. Using the DPSV rule, sectoral investment is constrained to follow capital.

From the expenditure side of the economy, household consumption is set to closely follow GDP in the long-run. Similarly, government consumption and imports are expected to follow household

[4] Includes water used by households.

[5] We would like to thank one of the referees of this paper for this suggestion.

[6] See Dixon et al., [120] and Bohlmann [121] for a thorough description of the technical details behind the structure of CGE models.

consumption and they are endogenous. This implies that both the average propensity to consume and the ratio of private to public consumption are exogenous. Exports are determined as a residual to balance GDP from the expenditure side with GDP from the income side. In order to cater for the macro-environment in the closure i.e., the relationship between the domestic economy and the rest of the world, the dynamics of a small open economy are employed. In this regard, changes in the domestic demand and supply conditions have no effect on the rest of the world prices. Therefore, exports and imports prices are exogenous. Under the short-run closure, we set the trade balance to be endogenous on the belief that, it is possible for the economy to run on deficit on the trade account in the short run. However, since no country can run on a trade deficit indefinitely, it is only natural to fix the trade balance over time. Hence, the trade balance is set to be exogenous under the long-run closure. Finally, our numeraire is the nominal exchange rate.

6. Results and discussion

6.1. Macroeconomic level results

In this paper, three sets of simulations are carried out using the using the modified UgAGE model. The first set of simulations is an imposition of a UGX 500 (US$20cents per m^3) tax on commercially supplied water [17]. The imposition of a tax is expected to generate government revenue. In our modelling framework, the imposition of a tax is accompanied by three revenue plough back schemes on sales, production taxes and export taxes such that the overall policy change is revenue neutral. This is done for both long-run and short-run closure conditions for the selected industries. Table 3 presents macro level results from the tax simulations and revenue plough back schemes of the proposed policy interventions. The modelling framework is applied to show results from the different policy mixes. The linearity property of the model allows the percentage changes for particular shocks to be summed up in order to yield the total effect. The analytical process evolves as follows: when a tax is levied, (i) taxes increase the cost of production and therefore decrease the supply of most commodities, while

Table 3
Results of main macro variables (percentage changes).
Source: Author's computations.

Variables	Environmental tax		Revenue plough-back scheme					
	Water tax		Sales tax		Production tax		Export tax	
	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run	Short run	Long run
Agg revenue ploughed-back	5.04	−2.49	−219.3	−219.6	−219.7	−219.4	−219.4	−219.7
Aggregate revenue generated	219.74	219.65	0	0	0	0	0	0
Aggregate employment	−0.36	0	0.25	0	0.35	0	0.66	0
Terms of trade	0.35	0.09	−0.41	−0.51	−0.36	−0.22	−2.07	−2.88
Consumer price index	0.33	0.11	−0.43	−0.47	−0.29	−0.14	0.48	0.44
Exports prices	0.35	0.09	−0.41	−0.51	−0.36	−0.22	−2.07	−2.88
Nominal exchange rate	0	0	0	0	0	0	0	0
Real wage	0	−1.13	0	1.06	0	2.74	0	2.76
Real GDP	−0.15	−0.14	0.11	0.23	0.16	0.61	0.29	0.52
Export volume index	−0.51	−0.24	0.53	0.65	0.45	0.10	2.14	2.78
Imports	0.11	−0.13	0.04	0.002	−0.18	0.04	0.62	−0.01
BOT contribution to real GDP	−0.15	−0.01	0.11	0.15	0.16	0.01	0.29	0.63
Capital stock	0	−0.34	0	0.48	0	1.22	0	1.03
Aggregate primary factor use	−0.17	−0.16	0.12	0.22	0.16	0.56	0.30	0.48
Aggregate real investment	0	−0.33	0	0.51	0	1.26	0	1.17
Real household consumption	0	−0.06	0	−0.04	0	0.36	0	−0.41
Real government demands	0	−0.06	0	−0.04	0	0.36	0	−0.41
Aggregate real inventories	0	0	0	0	0	0	0	0
Volume of taxable water	−12.37	−12.36	0.11	0.13	0.141	0.24	0.22	0.17

(ii) the increase in government revenue without a concomitant increase in government expenditure decreases aggregate demand. Since both capital and skilled labour face inelastic supply in the short-run, the fall in aggregate demand causes a significant reduction in price levels and a decline in real GDP. This leads to a decline in the volume of taxable water used. The increase in domestic prices leads to a decline in exports of most commodities and an increase in imports. The plough-back schemes work in the opposite direction.

The focus of the analysis is mainly on the sustainability of the proposed intervention with regard to economic performance as well as water resource use. In this regard, the interpretation and discussion of results pays more attention the results from the long-run closure. On the issue of sustainability, the policy is sustainable with regard to its water use. From Table 3, the reduction in water use following the imposition of the tax is larger than the increase in water use following the revenue plough-back process. In fact, the trajectory of water consumption is more less the same in both closures.

With the imposition of a tax, prices rise, leading to a decline in exports and an improvement in terms of trade in the long run. Furthermore, real wages decline by 1.13 percent, investment, imports decline as well due to the reduction in domestic demand. This leads to a decline in real GDP. Conversely the plough back of the generated revenues leads to a decline in prices. With aggregate employment fixed, the increase in demand following a tax plough-back scheme raises real wages. However, the increase is real wages is higher under the export tax plough back scenario (2.76 percent) compared to the 1.1 and 2.64 percent under the sales tax scenario and production tax scenarios. Aggregate investment increases and as well as factor use. A fixed rate of return allows capital stock to increase by 0.48, 1.22 and 1.03 percent under sales tax, production tax and export tax schemes respectively. Private and public consumption increases under the production tax scenario but not under the sales tax.

The increase in components of aggregate expenditure leads to different levels of increase in real GDP for the three revenue plough back schemes. The production tax scheme represents a more optimal policy intervention for the macroeconomy in the long run with a desirable increase in real GDP of 0.6 percent compared to the 0.22 and 0.52 percent under the sales tax and export tax breaks, respectively. This difference in performance could be attributed to the channels though with the three taxes affect the components of aggregate demand. For instance, the sales tax is more thinly spread across intermediate inputs, investment, households, individual and collective exports and on sales to government. This is in stuck contrast with the production tax which is only directed towards production activities, thereby having a higher positive impact. Despite the increase in real wages, the plough back schemes result in decline in export prices and an increase in export volumes. The price reduction induces a decline in terms of trade. However, the contribution of the trade balance to real GDP is positive in all the three plough-back scenarios. A critical analysis of the three plough-back schemes shows that sales tax produces fewer gains with percentages in the key macroeconomic aggregates being lower or negative than the production tax. For instance, private and public consumption declines marginally by 0.04 percent compared to a gain of 0.38 under the production tax scheme. Investment increases by 0.51 percent compared to 1.3 percent under production taxes. Overall, the effect on the economy of the imposition of a tax and plough-back of the resulting revenue is sustainable. From the macro level, the tax induces a reduction in water use under both short-run and long-run time horizons. The resulting increase in water consumption following the revenue plough-back is less than the initial decline and yet the effect of the plough-back on the economy is positive in terms of increasing real GDP. In order to put the subsequent analysis into perspective, Fig. 2 highlights the industry shares in the UgAGE model used. From the figure, agriculture and manufacturing constitute the largest shares according to the industry break down in our model. It is important to note that whereas agriculture is a larger industry relative to the rest, the combined effect of the rest of the industries outweighs that of agriculture depending on the scenario under consideration.

6.2. Environmental effects

In analyzing the environmental effects of the tax (first dividend), changes in water use are divided by changes per unit of tax revenues in real terms. The results are presented in Table 4 where a tax

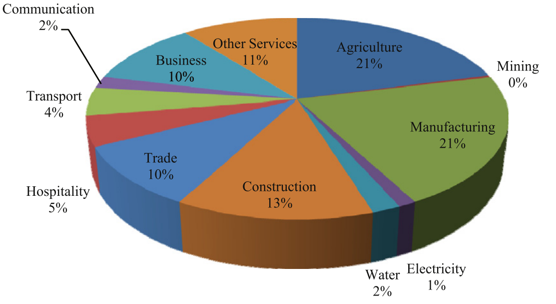

Fig. 2. Industry shares in the UgAGE model.
Source: Authors.

Table 4
Marginal changes in water consumption from imposition and plough-back of a tax.
Source: Author's computations.

Water tax Reduction in water consumption			**Sales tax break** Increase in water consumption		**Production tax break**		**Export tax break**	
	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run
Industry			0.001406	0.002667	0.001885	0.005697	−0.116794	0.00957
Agriculture	−0.02011	−0.02016	+	+	+	+	+	+
Mining	−0.02139	−0.02273	+	+	+	+	+	+
Manufacturing	−0.02034	−0.02005	+	+	+	+	+	+
Construction	−0.02068	−0.02093	+	+	+	+	+	+
Hospitality	−0.01097	−0.01053	+	+	+	+	+	+
Business	−0.00957	−0.00965	+	+	+	+	+	+
Other Services	−0.01339	−0.01327	+	+	+	+	+	+

Notes: The results in column 2 and 3 are percentage decreases in water use per UGX1 billion in tax revenue raised. Under the plough-back schemes (columns 4–9), the result 0.00141, 0.00189, and -0.116794 are the short-run average increases in water use for the respective schemes. If the increase in water use which follows the plough-back is less than the initial decrease following the tax, the net effect is a decline in water use and hence a plus (+) sign to signify an environmental dividend.

reduces water use, implying that for all the simulations, changes in water use following a tax yield the first dividend for the different industries. In addition, all three plough-back schemes yield an environmental dividend. This implies that the environmental benefits associated with the reduction in water use are realized irrespective of the channel through which the collected revenue is ploughed back into the economy. Essentially, the first dividend is confirmed to exist under the plough-back schemes only if there is a net reduction in the amount of water used per unit of real government revenue ploughed back. From the results, we see that a tax on water consumption always leads to a decrease in water use under the two time horizons (Table 4, column 2 and 3). Whereas water consumption increases following the revenue plough-back process, this increase is less than the initial decrease in water use following the tax (column 4–9) hence an environmental dividend.

From the table, a tax on agriculture results in a decrease in water consumption by the sector of 0.0201 percent per UGX1 billion of realized tax revenue. All changes in water consumption are expressed in terms of percentage changes per UGX1 billion of revenue collected. On the other hand, a sales, production tax or export break through plough-back increases economic activity. As a result, more water is consumed. For example, a sales tax break increases water consumption by 0.002667 percent on average per industry for each UGX1 billion in ploughed-back tax revenue. A combination of a tax on agriculture and a sales tax break involving the same amount of revenue, results in a net decrease in water demand. A comparison of the three plough back schemes shows that an export tax break results in a higher decline in water consumption.[7] From a sustainability point of view, the policy shows the presence of dividends under both time horizons.

6.3. Economic effects

6.3.1. GDP and employment effects

In order to assess the economic impact of the tax on the economy, we compute the Marginal excess burden (MEB). The marginal excess burden (MEB) is the change in real GDP divided by the change in real government revenue. In this case, we analyze how GDP declines as a result of an increase in total tax revenue. On the other hand we also assess the impact on GDP of a tax break through the three plough-back schemes. In this case, the MEB measures the increase in GDP per decrease in total tax revenues. Formally:

$$\text{MEB} = \text{change in real GDP}/\text{change in real government income}$$

The MEB is a proxy for the distortion which arises from the imposition of a tax. Given that the numerator and denominator are measured in monetary terms, comparing the MEBs for the different scenarios gives combinations of scenarios which produce a second dividend, i.e., an increase in GDP while maintaining total government revenue constant.

The MEBs for all water tax policy measures as well as the three plough-back measures are compared in Table 5 Column 3 and 4 presents the losses in GDP that accrue to the different industries following the imposition of a tax for the respective time horizons. A double dividend is indicated by a plus (+) sign. This implies that the increase in real GDP per unit of real government revenue lost as a result of a tax break is larger than the decrease in real GDP per unit of real government revenue collected from the tax for the respective industries. Otherwise, a minus (−) sign is indicated. From our computation, the results in Table 5 are interpreted as follows: When a water tax is levied on the agriculture industry and UGX1billion is realized in tax revenue, real GDP decreases by UGX6.5 million. Similarly, the MEBs are computed for the plough-back schemes producing values of 0.0011, 0.0023 for the sales break tax, 0.0016 and 0.0061 for the production tax break, and 0.00294, 0.00519 for the export break during the short-run and long-run time horizons respectively. From the results, a combination of a water tax on agriculture and the three tax breaks result in a decrease in real GDP. The results show that a tax on water for agriculture would be distortionary to the economy in the short and long-run because the net effect on GDP is negative despite the plough-back schemes. Similarly, taxing other services and ploughing back using a sales tax break would not yield a dividend in the short-run. However, for the rest of the industries; a tax followed by plough-back yields a double dividend for the economy for both time horizons and for all the three plough-back schemes. In Table 6, we present results of the percentage changes in aggregate employment per unit of government revenue for the short run time horizon since aggregate employment is endogenous in this case.

Generally, employment is closely linked to GDP. In this study however, the results of the percentage changes in employment per one billion of tax revenue follow a slightly different trend from that of the MEB results in Table 5 for the mining, hospitality and other services industries. From Table 6, a double dividend is realized for taxes to certain industries as well as for certain plough-back schemes. For instance, a water tax on the agriculture and mining industries would be distortionary, even when the taxes are ploughed-back using any of the schemes. The declines in employment for the largest sectors have implications for household welfare as the agricultural sector alone employs over 75 percent of the population. The export tax break performs better in correcting the distortion with respect to GDP performance compared to the sales and production tax breaks. However, the converse is true with respect to employment. Note however that the differences in performance of the tax and plough-back schemes emanate from utmost two industries in both cases. The analysis of changes in employment and output follow Table 9 in sub-Section 6.4.

[7] Due consideration was taken in the choice of water demand semi-elasticities used as they are fundamental in influencing the results. Different elasticities were tested over a wide range and there was no significant change in results for the variables of interest.

Table 5
Marginal excess burden from the imposition and plough-back of a tax.
Source: Author's computations.

Water tax			Increase in GDP					
Marginal excess burden			Sales tax		Production tax		Export tax	
	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run
Industry			0.0011	0.0023	0.0016	0.0061	0.00294	0.00519
Agriculture	−0.00655	−0.00652	−	−	−	−	−	−
Mining	−0.00018	−0.00017	+	+	+	+	+	+
Manufacturing	−0.00034	−0.00034	+	+	+	+	+	+
Construction	−0.00076	−0.00075	+	+	+	+	+	+
Hospitality	−0.00130	−0.00136	−	+	+	+	+	+
Business	−0.00098	−0.00097	+	+	+	+	+	+
Other Services	−0.00284	−0.00287	−	−	−	+	+	+

Notes: The results in column 2 and 3 are percentage decreases in real GDP per UGX1billion in tax revenue collected. Under the plough-back schemes (columns 4–9), the result 0.0011 and 0.0016 are the average increases in real GDP for the respective schemes. If the increase in real GDP following plough-back is more than the initial decrease which follows the tax, the net effect is an increase in real GDP and hence a plus sign to signify an economic dividend.

Table 6
Marginal changes in employment from imposition and plough-back of a tax.
Source: Author's computations.

Water tax		Plough-back scheme		
Marginal change in employment		Sales tax break	Production tax break	Export tax break
Industry		0.000237	0.00033	0.000655
Agriculture	−0.00087	−	−	−
Mining	−0.00187	−	−	−
Manufacturing	−0.00019	+	+	+
Construction	−0.000012	+	+	+
Hospitality	−0.00073	+	−	−
Business	−0.00017	+	+	+
Other services	−0.00037	+	−	+

Notes: The results in column 2 are percentage decreases in employment per UGX1billion in tax revenue collected. Under the plough-back schemes (columns 3 and 4), the result 0.000237 and 0.00033 are the average increases in employment for the respective schemes. If the increase in employment following plough-back is more than its initial decrease following the tax, the net effect is an increase in employment and hence a plus sign to signify an economic dividend.

6.4. Fan decomposition analysis of the changes in industry output[8]

Table 7 presents the results of the impact of the tax on industry output. If we take agriculture as an illustration, we show that the predicted changes in domestic output are derived from three effects:

i) The local market effect. i.e., an increase in domestic demand for agricultural output, whether domestically-produced or imported;
ii) The domestic share effect. i.e., a shift in local usage of agricultural output, from the imported to the domestically produced; or
iii) The export effect. i.e., an increase in the export of agricultural output.

[8] Named after Fan Ming-Tai of the Academy of Social Sciences, Beijing Institute of Quantitative and Technical Economics.

Table 7
Impact of the imposition and plough-back of a tax on industry output.
Source: Author's computations.

Industry	Environmental tax		Revenue plough-back scheme					
	Water tax		Sales tax		Production tax		Export tax	
	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run
Category: ***Taxed***								
Agriculture	−0.289	−0.372	0.127	0.205	0.162	0.272	0.014	−0.223
Mining	−0.377	−1.945	0.085	0.533	0.114	0.616	0.366	2.103
Manufacture	−0.081	0.268	0.196	0.695	0.435	2.196	1.057	4.030
Construction	−0.006	−0.304	0.008	0.471	0.013	1.179	0.008	1.034
Trade	−0.061	−0.018	0.099	0.28	0.147	0.934	0.447	1.262
Hospitality	−0.546	−0.089	0.45	0.175	0.5	−0.891	2.391	2.521
Business	−0.037	−0.113	0.044	0.292	0.072	0.932	0.041	−0.128
OthServices	−0.262	−0.15	0.128	−0.151	0.209	0.092	0.076	−1.136
Category: ***Non-taxed***								
Electricity	−0.051	0.168	0.062	0.162	0.054	−0.022	0.689	−2.566
Water	0.001	0.118	−0.002	−0.144	0.001	0.058	0.011	−0.706
Transport	−0.088	−0.039	0.079	0.124	0.077	0.267	0.052	−0.242
PostTelCom	−0.088	−0.135	0.05	0.023	0.049	0.083	−0.007	−0.835
General Government	−0.086	−0.143	0.059	0.023	0.04	0.254	−0.080	−0.616

Notes: The results are percentage changes in total industry output following the taxation and plough-back process.

In most cases, these effects tend to work in different directions. For instance, a water tax increases the cost of production which induces a decrease in foreign demand. As a result, local producers cut down on the level of supply thereby increasing the domestic price and facilitating import penetration. The essence of the Fan decomposition is to show the relative magnitudes of these three contributions to output change. Table 7 presents the results of changes in total industry output following a tax and plough-back schemes for all industries analyzed in the model. In order to provide a more detailed analysis of the decomposition, Table 7 gives a breakdown of the changes in shares in total industry output for some selected industries.

From Table 7, a tax induces a larger reduction in output for the taxed industries than the non-taxed. Nonetheless, the effects of the policy are felt across the economy. Similarly, the plough-back schemes show an improvement in output for most of the industries with the export tax break, recording the largest impact. However, for the taxed industries, mining, manufacturing and the business sector registered a much more increase in output from the plough-back scheme than the initial decline that followed the tax in the long run. This is the case for general government and transport among those in the non-taxed industries category. The breakdown of changes in shares of industry output following the policy intervention as analyzed in Table 8.

In Table 8, we select a few strategic industries for analyzing the effects of the policy intervention on the industry output as well as changes in shares of output for the two time horizons. For the selected industries, the local market contribution explains only part of the proportional reduction in output. For agriculture, the long-run decline in local market share is 0.052 percent out of the total decrease in output of 0.372 percent. For mining, the local market share decreases by 0.043 percent out of 1.95 percent while for manufacturing, it decreases by 0.011 percent. However, the decline in local market share is over compensated by the increase in domestic share and exports. In terms of a shift from the usage of local output from imported to domestic, we see that the tax induces a decline in the usage of local output, thereby increasing the amount of imported output for agriculture and mining sector output. However, the manufacturing sector recorded an increase in both share of demand for domestic outputs and exports thereby leading to an overall increase in total output despite the tax. Mining recorded the largest decline in industry output following the tax with exports being the source of this decline. The sales tax plough-back scheme shows an increase in the local market share of output for all industries, with exports

Table 8
Effect of a water tax and plough-back on the shares of industry output.
Source: Author's computations.

Industry	Local market		Domestic share		Exports		Total	
	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run
Senario 1: Water tax								
Agriculture	−0.085	−0.133	−0.029	−0.052	−0.175	−0.188	−0.289	−0.372
Mining	0.005	−0.043	−0.157	−0.773	−0.225	−1.129	−0.377	−1.945
Manufacture	0.026	−0.011	−0.063	0.193	−0.044	0.087	−0.081	0.268
Scenario 2: Sales tax break								
Agriculture	0.021	0.113	−0.011	−0.02	0.117	0.112	0.127	0.205
Mining	0.019	0.153	−0.062	0.079	0.128	0.301	0.085	0.533
Manufacture	0.029	0.153	0.014	0.254	0.153	0.289	0.196	0.695
Scenario 3: Production tax break								
Agriculture	0.084	0.532	0.002	−0.062	0.076	−0.198	0.162	0.272
Mining	0.032	0.476	0.049	0.125	0.034	0.015	0.114	0.616
Manufacture	0.03	0.625	0.266	1.043	0.139	0.528	0.435	2.196
Scenario 4: Export tax break								
Agriculture	0.249	0.496	−0.042	−0.159	−0.193	−0.560	0.014	−0.223
Mining	0.112	0.579	−0.801	−0.181	1.055	1.706	0.366	2.103
Manufacture	0.155	0.601	0.367	1.303	1.269	2.126	1.057	4.030

Notes: The percentage change in local sales is derived from both foreign and domestic sources. The local market component of the percentage change in domestic production is weighted by the value of local domestic sales. The domestic share component is calculated as a residual (see [122]). (No interactive term is concealed in the residual. Because these decompositions are specified in small change terms, the changes due to each part add up to the change in the whole.)

accounting for the largest share of changes in industry output. On the other hand, the production tax plough-back scheme recorded an increase in industry output with the local market share contributing to the proportion of this increase. A comparison of the three plough-back schemes indicates that with the exception of the agricultural sector, an export tax break induces a higher increase in industry output than the sales and production tax. We see that the increase in the local market share contributes greatly to the overall increase in industry output in the long-run.

Table 9 presents results of the impact of the policy intervention on employment in the economy. Note that although aggregate employment is fixed under the long-run closure, there are changes in employment within the various industries. Under the short run scenario, employment is endogenous. From the table, the imposition of the tax results in a decline in employment across taxed sectors as well as the non-taxed. The reverse is true for the plough-back schemes. In the long run however, some industries register gains in employment from the imposition of tax, specifically, manufacturing, trade, and hospitality. This could be attributed to improvements in water use efficiency. On the other hand, it is clear that industries for which water is a major input in their production such as mining, agriculture and construction register a decline in employment. The plough back schemes result in an increase in employment for all the schemes for most industries, with manufacturing being the major gainer in employment with 1.12 and 1.59 and 3.5 percent for sales tax, production tax and export tax plough-back schemes respectively. However, the sectoral losses in employment are varied under different plough-back schemes. It is probable that the reduction in taxes and the resulting increase in real wages induce substitutability away from labour in favour of capital for these labour intensive industries. Furthermore, since employment is fixed on the aggregate, increases in employment in some industries result in declines in employment in others.

7. Conclusion

The study set out to explore the possibility of using a water tax to generate positive effects for the environment and the economy using a modified version of the UgAGE model was used. Given the

Table 9
Impact of the imposition and plough-back of a tax on employment.
Source: Author's computations.

Industry	Environmental tax		Revenue plough-back scheme					
	Water tax		Sales tax		Production tax		Export tax	
	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run
Category: ***Taxed***								
Agriculture	−0.853	−0.283	0.376	0.031	0.48	−0.232	−0.853	−0.863
Mining	−1.814	−2.035	0.37	0.253	0.462	−0.224	−1.814	1.506
Manufacturing	−0.184	0.539	0.497	0.441	1.12	1.59	−0.814	3.543
Construction	−0.012	−0.1	0.014	0.24	0.021	0.612	−0.012	0.498
Trade	−0.09	0.192	0.186	0.074	0.248	0.417	−0.09	0.822
Hospitality	−0.786	0.026	0.652	0.067	0.723	−1.304	−0.786	2.496
Business	−0.178	0.243	0.245	−0.089	0.438	0.019	−0.178	−1.033
Other services	−0.393	−0.085	0.176	−0.304	0.304	−0.242	−0.393	−1.592
Category: ***Non-taxed***								
Electricity	−0.167	0.462	0.205	−0.156	0.177	−0.79	−0.167	1.845
Water	0.004	0.411	−0.004	−0.461	0.003	−0.707	0.004	−1.404
Transport	−0.198	0.195	0.176	−0.134	0.171	−0.37	−0.198	−0.857
PostTelCom	−0.224	0.131	0.135	−0.271	0.119	−0.647	−0.224	−1.485
General government	−0.091	−0.098	0.065	−0.02	0.041	0.145	−0.393	−0.711

Notes: The results are percentage changes in total industry output following the taxation and plough-back process.

limited use of taxes in environmental regulation and fiscal policy, the results highlight issues which are vital for policy decision making. This is given the fact that environmental resources are experiencing challenges, most of which emanate from economic and human activity. This calls for the need to institute measures to regulate such activities in a sustainable manner. Similarly, as policy makers seek to find ways of widening the tax base, it is important to investigate the viability of using environmental taxes for purposes of domestic resource mobilization which this study has undertaken in part. Specifically, a tax of US$20 cents was used in this study because the objective was to assess whether or not a water tax can yield dividends in a developing country context. Different tax rates were tested and the results proved to be highly sensitive to the tax rates used. Overall, the results show that it is actually possible to generate positive dividends for the economy.

The paper finds that a neutral fiscal policy which introduces a tax on water with an equivalent revenue plough-back scheme yields dividends for the economy in the long run. In addition, the results show that the policy is sustainable when assessed from the persistence of both environmental and economic dividends using the long-run time horizon. From the results, water demand remains more or less on the same trajectory in the long-run and in fact, a higher level of dividends is realized. However, the realization of any dividends depends upon the sectors on which the tax is imposed, the tax rate and the choice of plough-back scheme. For instance, some studies impose taxes on specific sectors as is the case with this study. However, the plough-back is usually done across the board. In this study, simulations which involved revenue plough-back across the board did not yield any dividends. This implies that only a deeper understanding of a given economy and careful policy design can lead to the realization of dividends from environmental taxation. Whereas the dividend hypothesis asserts that there are gains that accrue from environmental taxation, there is no guarantee that this bound to occur. Therefore, results cannot be generalized across economies.

The relevance of the study goes beyond environmental taxation in Uganda in that it can be extended to other developing economies whose use of environmental tax instruments is still limited and yet these economies stand to suffer from the adverse effects that may arise from environmental resources mismanagement. Given the fact that water resources constitute only one of the multiple environmental problems being faced globally, the need to utilize environmental tax instruments for purposes of economic and environmental management especially in the developing countries cannot be over emphasized. Finally, the potential for the generation of dividends can only be realized under certain conditions. This implies that a different analytical set up may yield dividends from a different choice of industries and tax policies from the ones which have been tested in our model. The results from the analysis of a specific policy intervention will depend on the existing conditions for the economy in question. In this study, we mainly focused on establishing whether it is possible to generate revenue, reduce water consumption and increase economic growth, and employment all at the same time. The findings show that depending on the set up, it actually is.

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