ECONOMIC VALUATION OF IRRIGATION WATER: EVIDENCE FROM LOWER MOSHI IRRIGATION SCHEME IN TANZANIA

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ABSTRACT

Water scarcity is globally getting worse in the light of increase in demand for water use. Human and ecosystem health and economic development are affected by problems of water scarcity and water pollution. This article assessed the economic value of irrigation water in crop production around the Lower Moshi Irrigation Scheme in Tanzania. Specifically, the study determines and estimates economic value of paddy and maize using Residual Imputation Method while the Change in Net Income Approach was used to compute the net output values. Household questionnaires, checklist for key informants and participant observation were employed for data collection. Questionnaire survey was administered to 105 households to establish the major agricultural activities, crops, costs of production and income accrued from these activities. Data relating to household characteristics and water related economic activities were analysed using LiMDEP 12 statistical software whereby Microsoft Excel was employed to analyze data and quantify benefits accumulated from water (returns). Findings revealed that, 78.3 percent of the respondents own land and 21.7 percent of them rent the land for crop production. The net values of water for irrigated paddy and maize were estimated to Tshs 661.2 (US$ 0.413 per m^3) and Tshs 329.25 (US$ 0.21 per m^3) respectively. Furthermore, the results indicated that, the more profitable enterprise is irrigated paddy with a profit margin per Ha of Tshs 2,467,611, followed by maize with a profit margin per Ha of Tshs 742,450.

Keywords: Value of Water, Residual Imputation Method, Paddy, Maize

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1.0 Background

Globally, water is becoming an increasing scare resource which causes the demand for human need to grow at more than twice the rate of the population increase during 21st century and already a number of regions are chronically short of water (Molle *et al.,* 2008). In addition, water scarcity and its impacts on agricultural production and food security are growing concerns worldwide (Esmaeili *et al*., 2008).

Water has been recognized as a scarce resource by the international community since the 1992 Dublin Statements which clearly stated that water resources are not infinite and they are "vulnerable" (WMO, 2007). The fourth principle of 1992 Dublin Statements defines water as an economic good. The first principle of the 1992 Rio statements that supplemented the fourth Dublin principle implicitly suggests that water is a social good; therefore humans are entitled to at least certain levels of water especially under the responsibility of their respective governments (Briscoe *et al*., 1996; Dinar *at al.,* 2005).

Irrigated agriculture is important because it constitutes a driving force of both food productivity and agricultural income. As an immediate consequence of the climate and the socio-economic structure, water is not only an essential input for a profit-making agriculture, but also, for the economic viability and the social coherence of various rural areas. Irrigation water is one of the most important inputs for agricultural production, (Latinopoulos, 2008). Reliable sources of irrigation water especially in arid and semi arid areas reduce risk and stabilize agricultural production (Tarimo *et al.,*1998; (Esmaeili *et al*., 2008).

As irrigation is a major user of water (about 50% to 70 % of global water resources) (Kadigi, 2006), developments in irrigation have a reflective impacts on basin-wide water use and accessibility. Yet, planning and implementation of irrigation projects frequently take place without consideration of other uses. One of the main reasons for this restricted view of irrigation workers is inadequate means to describe how irrigation water is being used. Irrigation efficiency is the most commonly used term to describe how well water is being used. But increases in irrigation efficiency do not always coincide with increases in overall basin productivity of water (Molden, 1998; Postel, 2001).

Irrigated agriculture in Africa is under renewed attention in relation to food security and poverty alleviation, as a driver in agricultural development and for transformation of subsistence production, but also it causes externalities to the environment due to poor water use efficiency which lead to loss of ecosystem functions and services restored by inflow of rivers (Kalunde, 2008).

Protection of the environment is becoming one of the major goals of civil societies, (Maganga *et al.*, 2001). Awareness of the direct and indirect benefits of ecosystems services is increasing among the general public and at political levels and the protection of wetlands, forests and biodiversity is moving up on the agenda. Ecosystem products do have a significant value and can represent an important source of income for rural and urban communities (Laurie e*t al.,* 2002). Wetlands, for example, which exhibit large diversity in size and shape, are complex, dynamic ecosystems that help and protect rivers and lakes by storing nutrients and reducing sediment loads. Considerable progress needs to be made in the science and art of wetlands development planning and management to conciliate production and conservation objectives (Laurie e*t al.,* 2002).

Wherever water is scarce, whether because of natural shortage or inadequate allocation, ways need to be found for its best possible use such as allocation efficiency which addresses how water should be allocated among social strata, sector, activities and regions in order to achieve the most worthwhile overall use across sectors in the society (Muhammad *et al.,* 2005).

Tanzania's main water users are industry, irrigated agriculture, fisheries, wetlands and hydro-power generation. With a large and rapidly increasing population of 36 million, 80% live in rural areas, there are many and often conflicting pressures on the nations water resources. Although there is a theoretical priority in water resource allocation and development for domestic supply, in reality considerably greater resources are put into irrigation (for food security) and hydropower (for energy security) schemes (Turpie e*t al.*, 2003).

In Tanzania irrigation is important for rural development since it generates income for farmers, creating employment opportunities, and enhancing food security and alleviation of poverty. The growing water scarcity, farmers and other water users should increase pressure on efficiency use of this resource. This has led many governments in developing countries to point out efficiency use of water resources as one of the fundamental goals in their national policies (Kadigi *et al.,* 2006).

Rational decision making about water management issues requires reliable estimates of the economic value of irrigation water and riverside wetland services provided by restoration of river inflow such as control of erosion, purification of water, e.t.c (Molle, *et al.*2008; Speelman *et al*., 2008). Knowledge of these values are necessary when, for instance, making investment decisions concerning water resources development, policy decisions on sustainable water use and water allocations, or when the socio-economic impacts of water management decisions must be determined (Molle *et al.,*2008). Specifically for the agricultural sector, this knowledge is important to design fair, informed and rational pricing systems, providing incentives to irrigators to use water efficiently and allowing sustainable riverside wetland services provided by restoration inflow of the river (Speelman *et al*., 2008).

1.1 The Study Area

The Lower Moshi irrigation community, considered here as a multi-ethnic society, once practiced local (traditional) irrigation techniques before it was selected by the government and donor agencies for 'modern' irrigation development. The Lower Moshi area lies in the Kilimanjaro region of north-eastern mainland Tanzania, bordering Kenya to the north, the Arusha region to the west, and the Tanga region to the south-east. The region has six districts: Hai, Rombo, Same, Moshi Rural, Moshi Urban and Mwanga. The Lower Moshi irrigation scheme is located in Moshi Rural, 6-20 km south west of Moshi town, the capital of the Kilimanjaro region of Tanzania. Administratively, Lower Moshi is divided into four villages, namely Mabogini, Chekereni, Rau and Oria. The extent of the local irrigation experience of farmers living in the Kilimanjaro region was revealed by Ikegami (1995) as cited by Kalunde (2008) who found 45 100 Ha of irrigated land within the Kilimanjaro region, i.e. about 28% of the arable land in the region (4% of the total arable land of Tanzania).

In the Lower Moshi irrigation scheme, the project area consists of a relatively narrow strip of land developed on alluvial plains along the right bank of the RauRiver. It is bound by the RauRiver on the east, the sugar plantation of Tanganyika Planting Company (TPC) on the west and north and by the National Agriculture and Food Cooperation Farms (NAFCO) on the southern side. The rainfall distribution in the area is bimodal, with two distinct seasons (short and long rains): the short rains fall betweenNovember and February, and this lesspredictable rainfall season is called vulli, while the long rainy season (March and May) is locally termed masika. The dry season (kiangazi) falls in the period of June to mid-November or December. Mean temperatures range between 21^{o}C and 26^{o}C, and are suitable for irrigated paddy cultivation (JICA 1980).

The scheme is one of the older improved systems modernized through a loan from a donor agency to the Tanzanian government. It is a jointly managed (government/farmer) scheme that has not received any previous detailed research. The whole scheme is treated as a case study site, encompassing four villages which are, Mabogini, Rau, Oria and Chekereni. The methodology chosen to address the research question involves an interdisciplinary combination of qualitative and quantitative approaches.

4.5 Water Management in Tanzania

Accoring to FAO, 2008, the responsibility for managing the water resources of the country lies with the Ministry of water and livestock Development (MWLD). Water resources management involves water resources development, water allocation, pollution control, and environmental protection. Until the 1990s, water was managed by the MWLD on the basis of administrative regions. Since then, the emphasis has changed to managing water resources on the basis of river basins. To strengthen river basin management, the MWLD was implementing the river basin management component of the River Basin Management and Smallholder Irrigation Improvement Project (RBMSIIP) in the Rufiji and Pangani basins. The project, the implementation of which began in December 1996, was intended to deal effectively with water management problems and improve the efficiency of smallholder irrigation.

Irrigators' Associations (IAs), or Irrigators' Groups (IGs), have been formed from the early 1990s onwards, for example in the Pangani basin. They are expected to become a main actor in the irrigation sector, representing part of the private sector. The rights and obligations of these groups cannot always be clearly and uniformly defined under the present legal framework. A new legal framework for the IGs seems to be very important and necessary (FAO, 2008).

4.6 Policy and Legislation

The regulatory and institutional framework for water resources management is provided for under the Water Utilization (Control and Regulation) Act. No.42 of 1974 as amended by the Water Laws (Control and Regulation) Act of 1997 and the Water Laws (Miscellaneous amendments) Act of 1999. They stipulate that all water in mainland Tanzania is vested in the United Republic of Tanzania and the Minister responsible for water development is empowered to regulate the use of water from any source in any area of the country on a national basis, to declare such a source to be a national water supply for the purpose of the Act. The Law sets conditions on the use of water and appoints the Principal Water Officer, under the direction of the CWB, to be responsible for setting policy and allocation of water rights at the national level. The Water Act is currently under review. The new Act is expected to establish a mechanism for a more participatory management of water resources. With irrigation an important economic activity in most if not all of the river basins of the United Republic of Tanzania, a more balanced approach will probably be adopted.

In 1994, the National Irrigation Development Plan (NIDP) was prepared including the objectives of "Removal of Sectoral Constraints" and "Implementation of Irrigation Infrastructure". Progress so far has only been about 30 percent for the components related to both the objectives mentioned above, while completion is envisaged by 2014. The main reasons for the slow progress are inadequate institutional reforms and lack of human and financial resources.

Existing land tenure arrangements do not attract long-term commitments of resources for improving the productivity of land through irrigation or drainage. The 1999 Land Act has laid the foundation for a more transparent execution of land-based transactions and property rights. However, problems in the administrative procedures and in the use of land as collateral for obtaining credit still need to be addressed.

The Agricultural Sector Development Strategy (ASDS), finalized in 2001, focuses on the period 2002-2007 and proposes to apply the principles of integrated soil and water management, emphasizing the use of low-cost approaches by smallholders and to promote and support small-scale irrigation.

In July 2002, the Government issued the National Water Policy whose main goals are to establish a comprehensive framework for sustainable development and management of water resources and for participatory agreements on the allocation of water use. The Government will not be in charge of executive functions, i.e., the actual delivery of the services, which are the responsibility of the LGAs. Central statements of the Policy are that "water will be subject to social, economic, and environmental criteria" and that "every water use permit shall be issued for a specific duration". This could mean that irrigation might have to compete with industrial sectors and that a continuous irrigation water supply might not be guaranteed (FAO, 2008).

2.0 Methodology

2.1 Data Collection

The study was conducted in Lower Moshi irrigation Scheme which covers Chekereni, Oria, Mabogoni and Rau villages where primary data were collected. A combination of data collection tools were used in data collection such as focus group discussion, structured questionnaires and participant observation. This amalgamation of methods was used to harmonize each other because of limitations by one method and allows proof of answers (Olsen, 2004). A sampling unit for this study was a household which was randomly selected in all villages with 5 percent as the sampling intensity for households in each village. A random sample should represent 5 percent of the total population as a representative of that population (Bailey, 1994). A total of 120 households were interviewed where both qualitative and quantitative data were collected. Information such as crop production (both paddy and maize), land size in acreage, cost of inputs such as fertilizer pesticides, herbicides, improved seeds, quantities of yield produced, and prices of output produced and the quantity of yield sold and consumed by household.

Secondary data such water consumption and price of irrigation water in paddy and maize production were obtained from Lower Moshi Irrigation Scheme office and Kilimanjaro Agricultural Training Center (KATC).

2.2 Data analysis

The Limited Dependent (Lim-Dep) 4.0 Software was used to get hold of descriptive statistics. Microsoft Excel was employed to analyze data and quantify benefits accumulated from water (returns). However, different analytical tools were also used to analyze benefits of water in paddy and maize production. The method used to estimate the economic value of water was Residual Imputation Method (RIP) while the Change in Net Income Approach (CINI) was used to compute the net output values. This method has been proven to be a useful tool by providing desired results. It has been widely used by different authors (Kadigi *et al.,* 2004; Musamba *et al.,* 2011) to calculate the net output values of crop production.

$$NOV = Y_c * P - C_{pr} - C_L - C_{FL} - C_{HL} - C_W \qquad (1)$$

Y_C is the crop yield; P is the unit price of crop output, C_{pr} all variable costs (Improved seeds, fertilizers, pesticides, insecticides, and transport C_L is the land rental price; C_{FL} is the cost of family labour, priced at the average hired labour wage, including field operation and management; C_{HL} is the cost of hired labour; and CW is the irrigation fee (water use fee/cost).

The Residual Imputation Method was applied to estimate the economic value of water for irrigation, where data on production cost and revenue were used to estimate an economic value of water. Residual valuation assumes that if all markets are competitive except for water, then the total value of production exactly equals the opportunity costs of all the inputs.

For an agricultural production process in which crop (Y) is produced by the following factors of production: capital (K), labour (L), and other natural resources such as land (R) and irrigation water (W). The production function was specified as:

$$Y = f(K, L, R, W) \qquad (2)$$

If competitive factor and product markets are assumed, prices can be treated as constants. By the second postulate, it then follows that:

$$TVP_Y = (VMP_K * Q_K) + (VMP_L * Q_L) + (VMP_R * Q_R) + (VMP_W * Q_W \qquad (3)$$

Where

TVP - represents total value of product Y ;

VMP - represents value marginal product of resource i ; and Q is the quantity of resource i . The first postulate, which asserts that, $P_i = VMP_i$ permits substitution of P_i into (3) and rearrangement of the same equation as follows:

$$TVP_Y - [(P_K * Q_K) + (P_L * Q_L) + (P_R * Q_R)] = P_W * Q_W \qquad (4)$$

On the assumption that all variables in (4) are known except P_W that expression can be solved for that unknown to impute the value (shadow price) of the residual claimant, (water) P_W, as follows:

$$P_W = \{TVP_Y - [(P_K * Q_K) + P_L * Q_L) + (P_R * Q_R)]\} / Q_W \qquad (5)$$

The Residual Imputation Method (RIM) has been used to derive the economic value of irrigation water (Kadigi *et al*,. 2004 and Young, 1996) as cited by Musamba *et al*., (2011). The method identifies the contribution of all inputs to the value of total output where simple and advanced analytical models can be used. Experience has shown that many researchers have centered their analysis on simplicity of the functional forms giving little attention to other factors (e.g., the nature of factor substitution, whether variable, constant or a unit). In sense, these may dictate the forms (e.g., constant elasticity, production function, variable elasticity production function and unitary elasticity production function). For ‘‘intermediate good uses’’ of water, models of the ‘‘profit-maximizing’’ firm can be used. However, the general characterization of most rural producers (peasants) in developing countries as risk aversors, drudgery aversors, sub-optimal producers, partial engagers in incomplete markets, and the like, would make these models to be seen as inadequate portrayals. Ellis (1996, disputes that that elements of the economic calculus characterized by ‘‘profit maximization’’ are roughly present in peasant economic performance.

3.0 Results and Discussion

3.1. Socio-economic characteristics of smallholder farmers

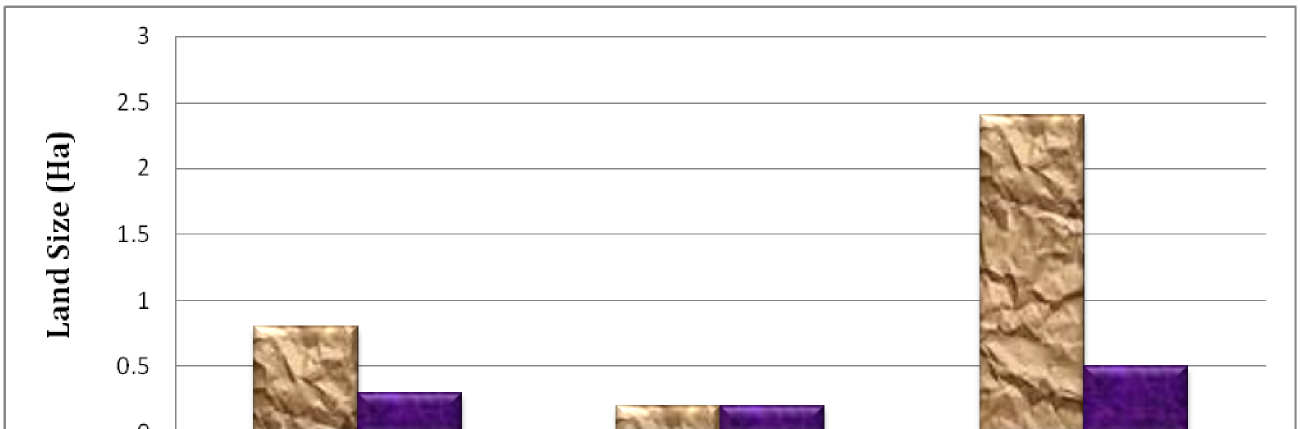
From the results presented in the Table 4, 55.2% of respondents were males while 44.76% were females. However, in Oria village, males and females were approximately equally represented during the interviews. The age of respondents is 38.76years with the standard deviation of 11.09 years. Educational status of the respondents was found to be at primary school level (60.93%) followed by form four levels (21.9 %) while 17.4% of the respondents were followed by form six and higher level each 8.57%. The respondents lived in nuclear family system and had an average of four members in their family. Majority of the respondents (81%) were engaged in agriculture followed by both agriculture and business (19 %).

3.2 Land Size for Households

From the results presented in the figure 1, the average land area owned by the household from the sample respondents and under cultivation was 0.8 ha for paddy and 0.3 Ha for maize. Findings show that about 78.3 percent of the respondents own land as an input of production and 21.7 percent of them rent the land for crop production.

These results imply that land is accessed by local people in the surveyed villages and they can use it as an input for crop production. It also indicates that land is in the hands of majority and some people in the surveyed villages can access land through renting. The results of this study can be compared by that of Musamba *et al*., (2011) in Kilombero River Valley who reported that 88.3 percent of the respondents possess land as an input of production and 11.7 percent of them rent the land for crop production.

Figure 1: Distribution of respondents by farm size.



	Mean (Ha)	Minimum (Ha)	Maximum (Ha)
Paddy	0.8	0.2	2.4
Maize	0.3	0.2	0.5

3.4 Economic value for irrigation water

Table 1 provides a summary of the average revenue, average cost for non water inputs average residual revenue attributed to water, estimated volumetric water demand and value of irrigation water in Tshs for paddy and maize crop production. Most respondents (96.7%) reported that they were using agro-inputs such as pesticides, improved seeds, and fertilizers to mention a few in both paddy and maize production. The average costs for non water inputs in irrigated crop per Ha was for paddy and maize production were Tshs 1,639,310 (US$ 1,024.57) and Tshs 742,450 (US$ 425.05) respectively in a respective season. The average revenue from irrigated crop per Ha paddy and maize crop production in were estimated at Tshs. 4,106,921 (US$ 2566.83) and 1,422,529(US$ 889.08) respectively per season. Conversely, the economic value of irrigation water for paddy and maize production were Tshs 661.2 (US$ 0.413 per m^3) and Tshs 329.25 (US$ 0.21 per m^3) respectively.

Table 1: Comparison of value of water in irrigated paddy, maize and sunflower for smallholder farmers within Lower Moshi Irrigation Scheme per season

Parameters	Paddy	Maize
Average revenue from irrigated crop per Ha (Tsh)	4,106,921	1 422 529
Average cost for non-water inputs in irrigated crop per Ha (Tsh)	1,639,310	680 079
Average residual revenue attributable to water (Tsh)	2,467,611	742 450
Estimated volumetric water demand (m^3)	3 732	2 255
Estimated average value of irrigation water (Tsh/m^3)	661.2	329.25
Value in US Dollar per m^3	0.413	0.21

These results on estimated values of water in this study can be compared with those reported in other studies in developing countries like Tanzania and elsewhere around the World. For instance, Musamba *et al* (2011) the economic value of irrigation water of water in paddy production in Kilombero Valley is Tsh. 273.6 (US$ 0.23) and Tsh. 87.72 (US$ 0.07) for non-paddy production. The difference may be caused by varying cropping and land-use patterns, low growth in yield levels and agro-climatic factors for the Kilombero Valley as compared to Lower Moshi Irrigation Scheme. Additionally, the latter may have relatively high availability and accessibility of water. However, the key element for the higher water value of the latter is the low non-water inputs used by the farmers which lead to relatively low variable costs of crop production in Lower Moshi Irrigation Scheme. Kumar *et al.* (2008) as cited by Musamba *et al.,* (2011) suggested improvements of non-water inputs with better water management as an effective strategy for increasing yield and water productivity in India.

3.5 Returns to Labour, and Profit Margins

Returns to labour, profit margins and values of irrigation water were compared for two crops cultivated in the study area using both secondary and primary data collected during the study. The results are summarized in Tables 2. The gross margins and returns to labour were calculated from averages of individual economic data using average current prices as collected during the interview. Results of the analysis Table 2 indicated that the more profitable enterprise is irrigated paddy with a profit margin per Ha of Tshs 2,467,611, followed by maize with a profit margin per Ha of Tshs 742 450.

Table 2: Comparison of profit margins and return to labour in paddy, maize and sunflower production

Type of crop	Yield/Ha	Average price (Tshs)	Production costs (Tshs)	Profit margin (Tshs)	Return to labour(Tshs/Mandays)
Paddy	85.5bags	48 000	1 639 310	2 467 611	20 563
Maize	50.8bags	28 000	680 079	742 450	13 025

However, considering labour requirement and return maize has low returns to labour of Tshs 13,025 as compare to Tshs 20 563 of paddy. When profit margins per hectare are compared the differences among the above two crops would be described as determined more by the extent to which commercial inputs were used and less by the differences in economies of scale. As the evidence in this study indicates, commercial inputs were relatively very expensive and their use might have eroded a large share of profit margins. It should however be noted that, what is important from the household perspective might be the return to labour and not the gross margin.

4. 0 Conclusions

Irrigated Maize and paddy production requires a land with suitable soils characteristics and easy access to water of which is the function of the ability of the household to own or rent such a land. Despite its potentials, crop production has relatively small returns to cost ratio as compared to other land uses and yet it is the main water consumer in the study area. For irrigated crops such as paddy maize, the economic values were estimated to Tshs 661.2 (US$ 0.413) per $m^3$and Tshs 329.25 (US$ 0.21) per m^3 respectively of water respectively. The small return might be due to high input costs in the sector. Nevertheless, the opportunity cost of water transfer from irrigated paddy to other alternative uses downstream is considerable both at local and national levels. Although, return to cost ratio from agriculture is small, yet it is a very important land use especially by considering that about 81% of respondents are depending on agriculture followed by 19 % depend on both agriculture and business for their livelihood.

5.0 Recommendations

As per above conclusion, therefore, this paper recommends that emphasis should be put on effective and efficient use of water by applying drip irrigation in order to improve its productivity in agriculture sector. For example water requirement for paddy is different from that of maize, therefore applying water (irrigating) at the right time based on different plant water requirement may improve water use by avoiding water loss.

Pricing water is important not only for generating revenues but also for promoting efficient use of water resource A free or very low water charge encourages overuse, reduces the incentive for farmers to cooperate or participate in irrigation originations, and may result in low system productivity and poor conservation. The charges could also bring an ownership feeling to the farmers, which will ultimately lead to better use of available water and increased crop production. Furthermore the collecting irrigation fees should not create any discouragement for farmers to irrigate, which means that the cost recovery mechanism should be compatible with resource use. This can be achieved if the fees are treated as payment for the service rendered and not as tax.

6.0 Acknowledgements

The preparation of this work has been possible through the grace of our almighty GOD. We are grateful to the Kyela District Council, Tanzania, Department of Agriculture and Livestock Development for providing financial support for this study. This is gratefully acknowledged. We are also thankful to all people who participated in the data collection in the study area. Finally we are indebted to Water Use Association members, households, key informants, KATC management and Water Authorities for providing the required information and data for this study.

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