Effects of protected areas on welfare of local households: The case of Maasai Mara National Reserve in Kenya

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Abstract

1. Protected areas are vital for biodiversity conservation although some have been criticized for not providing adequate socio-economic benefits to local people. Yet, empirical studies on socio-economic impacts of protected areas that control for confounding factors are rare.

2. Here, we assessed the potential impacts of Maasai Mara National Reserve in south-western Kenya on welfare (indicated by levels of income, consumption and assets) of, and poverty incidence among, 423 randomly selected local households. We used descriptive statistics to summarize demographic and socio-economic statuses of the households. Then, we estimated effects of the protected area on welfare of the households using ordinary least-squares regression models and entropy balancing.

3. The protected area did not have a statistically significant effect on welfare of, and poverty levels among the households. Households that lived within a 5 km radius of the protected area boundary incurred significantly higher economic costs related to crop destruction and livestock depredation than households that lived 5–25 km from the boundary. Nevertheless, the majority of the households (86%) held positive views about the protected area due to its conservation role and direct and indirect benefits that they had already gained and expected to gain from it in the future.

4. These results suggest that interventions are needed to reduce economic losses caused by wildlife from the protected area and improve its social and economic benefits to local households.

Keywords: conservation, East Africa, pastoralist communities, poverty incidence, well-being

1 INTRODUCTION

Statutory protected areas have been established in different ecosystems worldwide to conserve biodiversity (Fandohan et al., 2015; Ferraro & Hanauer, 2015). Many statutory protected areas have been created through an exclusionary top-down approach, whereby local people are displaced with little or no compensation and are denied access to natural resources within the protected areas (Pullin et al., 2013). Prohibiting access to natural resources within protected area boundaries can have numerous negative social and economic impacts on local households.
economic impacts on local people who have traditionally relied upon those resources for their livelihoods (Mcelwee, 2010). Moreover, local people can incur additional costs such as crop losses, livestock depredation, and human injury and death caused by wildlife from protected areas (Long et al., 2020), which often leave them vulnerable (Sanderson & Redford, 2003). Nevertheless, local people can acquire various social and economic benefits from protected areas (Ferraro & Hanauer, 2014a, 2015; Stolten & Dudley, 2010). For instance, in Costa Rica, protected areas ameliorated poverty through provision of tourism revenues (Ferraro & Hanauer, 2014a). Tourism revenues have also been used to improve infrastructures in remote areas where protected areas occur (Ferraro & Hanauer, 2014a, 2014b). Local people are likely to support conservation if they accrue greater benefits than losses from protected areas (Ferraro & Hanauer, 2014b; Mojo, Rothsruh, & Alebachew, 2014). Therefore, mitigating negative impacts of protected areas and understanding factors that influence local people's attitudes towards them may help to improve sustainability of protected areas (Naughton-Treves, Holland, & Brandon, 2005).

In East Africa, arid and semi-arid ecosystems cover more than 50% of the total land area (Fratkin, 2001), and are home to many pastoralist communities and mammalian wildlife species (Reid, Thornton, & Kruksa, 2004; Seno & Tome, 2013). In those ecosystems, crop cultivation is not feasible and the availability of good quality pasture is highly variable across time and space; hence, pastoralism has been the principal livelihood strategy (Homewood, Trench, & Daniel, 2012; Seno & Tome, 2013). Traditionally, the primary mechanism of adaptation by pastoralists to temporal and spatial variability in pasture quality and water for livestock has been mobility over communal lands in search of the resources (Seno & Tome, 2013). Large areas of pastoral lands have since been converted into statutory protected areas (Fratkin, 2001; Reid et al., 2004). However, it remains unclear whether loss and fragmentation of pastoral lands to wildlife conservation have exacerbated pre-existing poverty levels, or whether conservation interventions have created opportunities for poverty alleviation. The pastoral landscapes historically had wide and deep levels of poverty even before establishment of the protected areas (Homewood et al., 2012). Case studies have used qualitative approaches to assess pastoral people's perceptions of social outcomes of protected areas (e.g. Homewood et al., 2012; Owino, Jillo, & Kenana, 2012; Wishitemi, Momanyi, Ombati, & Okello, 2015). Even so, studies that employ econometric approaches to estimate effects of protected areas on poverty levels in pastoral lands are lacking. Econometric approaches should complement in-depth qualitative analyses by providing objective and externally verifiable evidence (Woodhouse et al., 2015).

The relative proportions of benefits gained and costs incurred by local households in relation to a protected area may vary with the distance of a household from a protected area boundary (Mackenzie, 2012). For instance, a survey of households in 25 villages around Kibale National Park in Uganda found that although benefits were felt up to 15 km away from the park boundary, households that lived within a 0.5 km radius of the park boundary accumulated greater losses than benefits (Mackenzie, 2012). In contrast, in some cases, tourists can limit their activities to protected area boundaries (Novelli & Scarth, 2007), which may limit local households’ access to tourism-related benefits such as cash income from provision of cultural services and sales of goods to tourists at protected area entrances (Strickland-Munro & Moore, 2014; Wishitemi et al., 2015). Moreover, local households that own lands adjacent to protected areas may earn extra income from contractual conservation of wildlife (Oduor, 2020). Therefore, testing the relationship between a protected area and welfare of local households requires a comparison of welfare indicators between households living adjacent to a protected area versus distant households.

Here, we conducted a household-level survey around Maasai Mara National Reserve in south-western Kenya to determine whether, and to what extent the protected area affected livelihoods of local households. Specifically, we addressed the following question: (a) What are the perceived benefits and costs that are associated with the protected area? (b) What is the level of poverty incidence around the protected area? (c) What factors are associated with poverty incidence around the protected area? (d) What are the attitudes of local people towards the protected area?

2 | METHODS

2.1 | Study area

Maasai Mara National Reserve is a statutory protected area that was established in 1961 in south-western Kenya (Ottichilo, 2000; Figure 1). The reserve covers 6,400 km², which is approximately 25% of the Maasai Mara ecosystem (Ottichilo, 2000). The remaining 75% of the ecosystem is unprotected land inhabited predominantly by Maasai (Maa-speaking) pastoralists (Homewood et al., 2012; Ottichilo, 2000). The reserve is an undulating woodland savanna that lies at an altitude of 1,600 m a.s.l. The main tourism activities undertaken in the reserve include wildlife viewing and photography, safari and cultural tours, camping, balloon safaris and horseback safaris (Wishitemi et al., 2015). The reserve is unfenced and contiguous with unprotected lands to the north, east and west on the Kenyan side, and to Serengeti National park in Tanzania, to the south (Ottichilo, 2000). Human settlements and extractive use of resources including timber, firewood, medicinal plants, honey, bushmeat, trophy hunting, and livestock grazing are strictly prohibited within the reserve. The reserve hosts a high diversity of mammalian, avian, and reptile species, and is marked as a major tourist destination in East Africa (Ottichilo, 2000). For instance, 146,269 tourists visited the reserve in 2016 (Kenya National Bureau of Statistics, 2017). Maasai Mara ecosystem has high rural poverty levels (i.e. 30%-71% poverty head count ratio; Kenya National Bureau of Statistics, 2017). Therefore, the ecosystem is an ideal place to assess effects of a protected area on welfare of local households.
2.2 | Sampling and data collection

We collected data from households that lived adjacent to the protected area (i.e. within a 5 km radius of the boundary) and distant households (i.e. lived 5–25 km from the boundary). In addition, we assessed whether other social, demographic, and geographical factors affected welfare of the households (see Table 1; Table S1). We used a 5 km radius as a cut-off for adjacent versus distant households because a previous study found such a distance to cover localized impacts of a protected area (Hartter & Goldman, 2011). Ideally, longitudinal data (i.e. data from households in both intervention and control sites before and after establishment of a protected area) can provide a more robust estimate and full-fledged understanding of the impact of a protected area (Gurney et al., 2014). However, in our case, there were no baseline data available for the period that preceded establishment of the reserve. Therefore, our comparison of protected area-adjacent households, which may be more heavily affected by the protected area (equivalent to a treatment group) with similar households living distant from the protected area (equivalent to a control group) may still provide important insights into the socio-economic impact of the protected area (sensu Andam, Ferraro, Sims, Healy, & Holland, 2010).

We conducted the household surveys through face-to-face interviews with 423 randomly sampled households in six wards (i.e. administrative areas), each of which had a common border with the reserve (Figure 1). We used a stratified random sampling technique to select the households. First, we classified all the six wards into three groups using poverty headcount ratio (i.e. the percentage of individuals that lived below poverty line) data that we obtained from Kenya National Bureau of Statistics (Kenya National Bureau of Statistics, 2017). The groups are as follows: (a) 58%–71% (Naikarra ward), (b) 44%–57% (Angata Barikoi, Siana and Kimintet wards) and (c) 30%–43% (Mara and Lolgorian wards). Second, we selected within each ward all the villages that occurred within a 25 km radius of the protected area boundary using a topographic map from the District land and survey office. Consequently, a total of 72 villages were covered in the survey.

To ensure that each village was represented in the survey, the number of households surveyed per village ranged from four for small villages to eight for large villages. We used the most current national population census data of 2009 (Republic of Kenya, 2009) to classify the villages as small or large. The number of households per village ranged from 217 to 864, with a mean of 531. Therefore, we considered a village as relatively small when it had fewer than 531 households. Within each village, we obtained a list of all villagers from the local administrators, and then selected randomly households for interviews. We assigned each household a unique identification number, and then used a random number generator to select households for interviews. The interviews were conducted in January–March 2017. Questionnaire for the interviews contained both sets of closed- and open-ended questions to enable a comprehensive understanding of interviewees’ attitudes towards, and perceptions of benefits and losses
attributable to, the protected area from multiple perspectives. We defined a Maasai household unit as one headed by a man and comprised his wife (or wives), children and other dependents. This household unit is locally known as Olmarei. Although several Olmarei units often live together within the same compound referred to as Enkang, each Olmarei typically owns separate assets including livestock.

Interviews were made with household heads (males) in most cases, and with a spouse when the household head was away. In the interviews, we asked the respondents about demographic and socio-economic characteristics of their households, benefits and losses accrued by their households in relation to the protected area, and their attitudes towards the protected. The responses were translated from the local language (Maa) to English language, and all monetary values were recorded in the local currency (Kenya Shillings, KES). During the survey, distance of each household from the protected area boundary was also noted. The interviewees were given details in the local language about the objective of the study, and informed that the information they gave would be treated in confidence and their identity would not be revealed in any communication medium. No remuneration or gift was offered to them. The interviews were conducted by nine local research assistants. Approval for the study was granted by National Commission for Science, Technology, and Innovation of Kenya (NACOSTI); permit number NACOSTI/P/16/61809/13668). Ethical approval was granted by the university board. All study participants gave written informed consent.

2.3 Analytical framework and data analyses

We used descriptive statistics to summarize demographic and socio-economic statuses of the households. Then to assess impact of the protected area on welfare of the households, we did an empirical analysis in two steps. First, we estimated effects of the protected area on welfare using ordinary least-squares regression models and entropy balancing. Ordinary least-squares regression has been used by several studies to estimate welfare and poverty among rural households (Okwi et al., 2007). Entropy balancing is a technique that is employed to create a balanced sample, thereby controlling for confounding factors. Second, we determined a relationship between the protected area and poverty within the households using poverty indicators. We checked whether all assumptions of the ordinary least-squares regression were met using standard graphical methods and numerical tests and confirmed robustness of the results using entropy balancing. All analyses were performed with STATA 13.1 (StataCorp., 2013). For details of the econometric analyses, see the Appendix S1.

3 RESULTS

3.1 Demographic and socio-economic statuses of households around Maasai Mara National Reserve

Summary statistics of demographic and socio-economic statuses of the 423 households that we surveyed in six wards around Maasai Mara National Reserve are presented in Table S1. Costs and benefits borne by the households in relation to the protected area are also presented in Table S1. Fifty-four per cent of the households lived adjacent to the protected area (i.e. within a 5 km radius of the boundary), while the rest lived distant to the protected area (i.e. within 5–25 km). Ninety-nine per cent of the respondents (n = 419) were male household heads. The average age of the household head was approximately 44 years. About 60% of them had not attained formal education at all, while 25%, 13%, and 3% had attained, respectively, primary school, secondary school, and post-secondary school level education. Literacy level of household heads in the study population was lower than Kenya’s national average literacy rate of 85% (CountryWatch, 2017). The average family size of a household was approximately six individuals, with a dependency ratio of 0.88. That is, for every household member of a working age, there was approximately another dependent member in the household.

The average landholding size was approximately 26 ha, which was much larger than the national average of 1.2 ha (Syagga & Kimuyu, 2016). This could be because the survey area is occupied predominantly by pastoralists who require large tracts of lands for livestock grazing. Twenty-two per cent of the households (n = 93) had contracted portions of their landholdings for conservation of wildlife (i.e. were members of wildlife conservancies). The proportion of households that participated in contractual conservation was similar between protected area-adjoining and distant households. On average, a household had 53 livestock heads expressed in tropical livestock units. Approximately 45% (n = 190) of the households generated a part of their income from crop production. Approximately 22% (n = 93) of the households earned a part of their income from family member(s) who were employed in governmental or non-governmental organizations. In general, the average annual income of a household was KES 424,623 (median at 50% percentile = KES 280,425), of which 64% came from livestock rearing, 15% from crop production, 15% from employment, and 6% from other sources (e.g. donations from family members and friends). Whereas the estimated productive household assets were valued at KES 125,340, the estimated monthly per capita expenditure was KES 2,991.

Forty-three per cent of the households (n = 182) benefited from tourism and business activities related to the protected area. Specifically, 33% of the households (n = 140) reported that they had earned some non-monetary benefits such as community projects including development of infrastructure like schools, health centres, and water points for livestock, education bursary schemes for their children, and support of community enterprises. About 30% of the households (n = 128) earned approximately KES 16,125 per annum through gainful employment in the protected area, sales of artefacts to tourists, sale of livestock products to tourist camps and lodges within the protected area, and provision of cultural services like dances to tourists. On the other hand, 79% of the households (n = 334) had experienced crop damage and livestock depredation losses caused by wildlife from the protected area. The average annual cost related to crop raiding and livestock depredation was estimated at KES 65,968 per household. Despite the costs, 86% of the households (n = 364) held positive
attitudes towards the protected area due to direct and indirect benefits that they had already gained or expected to gain from it in the future.

3.2 Effects of Maasai Mara National Reserve, demographic, and geographical factors on household welfare

In Table 1, we present results of analyses to test the effects of Maasai Mara National Reserve, demographic, and geographical factors on household welfare. Distance from the protected area boundary, attainment of secondary school-level education by the household head, and benefits gained from the protected area were not significantly correlated with welfare indicators (annual household and per capita income, assets owned, and per capita expenditure). However, protected area-adjacent households incurred greater economic losses due to crop damage and livestock depredation than distant households. There was a significant variation in household per capita expenditure among wards. Households located in Kimintet, Mara, Naikarra, and Siana wards had significantly ($p < 0.05$) lower per capita expenditure than the reference ward, Angata Barikoi. Costs associated to crop raiding and livestock depredation were significantly ($p < 0.01$) lower in all wards than in Angata Barikoi ward. Age of the household head was not significantly ($p > 0.1$) correlated with income and assets, while per capita expenditure significantly ($p < 0.01$) increased with the age of a household head. A household headed by a person who had attained post-secondary school level education had, respectively, 66% and 86%

### Table 1

| Variable name                                      | Log total income | Log per capita income | Log assets | Log per capita expenditure | Log crop and livestock losses |
|----------------------------------------------------|------------------|-----------------------|------------|---------------------------|-------------------------------|
| Distance category                                  | 0.12 (0.09)      | 0.11 (0.09)           | −0.17 (0.14) | 0.06 (0.08)               | 0.96 (0.44)**                 |
| Age of household head                              | −0.01 (0.02)     | −0.01 (0.02)          | −0.01 (0.04) | 0.07 (0.02)**             | −0.05 (0.12)                 |
| Age of household head squared                       | 0.00 (0.00)      | 0.00 (0.00)           | 0.00 (0.00) | −0.00 (0.00)**             | 0.00 (0.00)                  |
| Sex of household head                              | 0.09 (0.51)      | 0.09 (0.51)           | 2.44 (0.80)** | 0.34 (0.43)               | 1.98 (2.52)                  |
| Education of household head (level 1)              | 0.11 (0.11)      | 0.11 (0.11)           | 0.35 (0.18)** | −0.04 (0.10)              | −0.39 (0.56)                 |
| Education of household head (level 2)              | −0.02 (0.15)     | −0.02 (0.15)          | −0.06 (0.23) | −0.12 (0.12)              | −0.44 (0.73)                 |
| Education of household head (level 3)              | 0.66 (0.25)****  | 0.65 (0.25)****       | 0.86 (0.39)** | 0.33 (0.21)               | 0.09 (1.21)                  |
| Family size                                        | 0.07 (0.14)      | −0.30 (0.14)**        | −0.02 (0.22) | −0.42 (0.12)**            | −0.21 (0.68)                 |
| Family size squared                                | −0.00 (0.01)     | 0.01 (0.01)           | −0.00 (0.02) | 0.02 (0.01)**             | 0.02 (0.05)                  |
| Dependency ratio                                   | −0.16 (0.07)**   | −0.17 (0.08)**        | −0.27 (0.12)** | −0.16 (0.06)**           | 0.23 (0.37)                  |
| Log landholding                                    | 0.18 (0.06)****  | 0.18 (0.06)****       | 0.09 (0.09) | 0.16 (0.05)****           | 0.13 (0.30)                  |
| Ward                                               |                  |                       |            |                           |                               |
| Kimintet                                           | −0.19 (0.19)     | −0.18 (0.19)          | −0.103 (0.30)** | −0.44 (0.16)**          | −2.93 (0.94)**               |
| Lolgorian                                          | 0.04 (0.14)      | 0.05 (0.14)           | −0.11 (0.22) | −0.21 (0.12)*             | −2.49 (0.70)**               |
| Mara                                               | 0.13 (0.21)      | 0.13 (0.21)           | 0.09 (0.34) | −0.57 (0.18)**            | −2.82 (1.05)**               |
| Naikarra                                           | −0.09 (0.18)     | −0.09 (0.18)          | −0.38 (0.29) | −0.52 (0.15)**            | −4.15 (0.90)**               |
| Siana                                              | −0.24 (0.21)     | −0.23 (0.21)          | 0.29 (0.33) | −0.45 (0.17)**            | −3.20 (1.02)**               |
| Income from crop production                        | 0.20 (0.11)*     | 0.21 (0.11)*          | −0.37 (0.18)** | −0.34 (0.10)**          | −0.81 (0.56)                 |
| Employment                                         | 0.70 (0.11)****  | 0.71 (0.11)****       | 0.53 (0.18)** | −0.06 (0.09)              | −0.32 (0.55)                 |
| Benefits from protected area                       | 0.04 (0.05)      | 0.04 (0.05)           | −0.01 (0.08) | 0.05 (0.04)               | −0.09 (0.25)                 |
| Income from land contracted for wildlife conservation | −0.41 (0.15)**   | −0.41 (0.15)**        | 0.14 (0.23) | 0.06 (0.12)               | 1.48 (0.71)**                |
| Constant                                           | 11.63 (0.77)**   | 11.51 (0.77)**        | 8.44 (1.20)** | 7.45 (0.64)**            | 10.65 (3.78)**               |
| $R^2$                                              | 0.25             | 0.29                  | 0.20        | 0.29                      | 0.09                         |
| N                                                  | 389              | 389                   | 389         | 390                       | 391                          |

Note: (a) ***denote 99%, **95%, and *90% confidence levels. Values in brackets are SE; the parametric estimate value of 0 for some variables such as age does not mean that it is exactly 0, but rather shows very small numbers (e.g. 0.00001) that after rounding off appear as 0; (b) These results were generated by ordinary least-squares regression models before being subjected to entropy balancing.
more income and assets than a household where the head did not attain formal education at all. However, attainment of secondary school-level education was not associated significantly \((p > 0.1)\) with income. Per capita income and expenditure decreased as the family size increased. Family size was not associated with total annual income, assets owned, and costs of crop raiding and livestock depredation that were incurred by the households. All the welfare measures significantly \((p < 0.05)\) decreased as the number of dependents in a household increased.

Landholding size was not significantly \((p > 0.1)\) associated with the value of assets owned by the households. Nevertheless, households with larger landholding sizes had higher total household and per capita income and expenditure. That is, a 100% increase in landholding size was associated with an increase of about, respectively, 18% and 16% in total household and per capita income and expenditure. Households that had contracted portions of their landholdings for wildlife conservation had less total household and per capita income and incurred greater crop raiding and livestock depredation losses than households that did not participate in contractual conservation. However, contracting of land for wildlife conservation was not associated with value of assets owned and per capita expenditure. Households that had at least a family member in formal employment had significantly higher \((p < 0.01)\) total household income and assets than households with no family member in employment. However, employment was not associated with per capita expenditure and losses from crop raiding and livestock depredation.

### 3.3 Effects of Maasai Mara National Reserve on household welfare after controlling for observable factors using entropy balancing

As explained in Section 2 of the methods (see Appendix S1), we used entropy balancing (a multivariate reweighting and matching technique) to assess whether there was a systematic difference (i.e. imbalances in the distribution of covariates) between households that lived adjacent to the protected area and distant households. After reweighting to create a balanced sample using entropy balancing, distance from the protected area boundary did not have any significant effect on the indicators of welfare, while protected area-adjacent households experienced significantly \((p < 0.05)\) higher economic losses related to crop raiding and livestock depredation by wildlife (Table 2). Therefore, there is no evidence that results of the ordinary least-squares regression presented above are biased due to observable factors. Because we made the comparison based on geographical position of households in relation to the protected area (i.e. distance category was treated as a variable of interest), it is unlikely that unobservable factors such as personal motivation may affect our results.

### 3.4 Poverty statuses of the households

Based on Foster–Greer–Thorbecke poverty indices (see description in the Appendix S1), 59% of protected area-adjacent and 66% of distant households lived below poverty line of USD 1.90 per day. On the other hand, 76% of protected area-adjacent and 85% of distant households lived below poverty line of USD 3.10 per day (Table 3). Results of regression analyses of factors that affected the depth of poverty (i.e. income gap expressed relative to the poverty line) are presented in Table 4. Like the case of welfare measures, there was no evidence that proximity to Maasai Mara National Reserve was significantly associated with the depth of poverty. An analysis that employed entropy balancing produced similar results (data not shown). Other factors including attainment of post-secondary school level education by a household head, size of land owned, and number of family members in employment as a source of income significantly reduced

| Variable         | Log total income | Log per capita income | Log assets | Log per capita expenditure | Log crop-livestock costs |
|------------------|------------------|-----------------------|------------|--------------------------|--------------------------|
| Distance category| 0.23 (0.12)      | 0.22 (0.13)           | 0.02 (0.17)| 0.18 (0.12)              | 1.23** (0.55)            |
| Constant         | 12.40*** (0.10)  | 10.72*** (0.11)       | 10.46*** (0.14)| 7.53*** (0.10) | 8.04*** (0.47)          |
| \(R^2\)          | 0.01             | 0.01                  | 0.00       | 0.01                     | 0.02                     |
| \(N\)            | 389              | 389                   | 389        | 390                      | 391                      |

Note: ***denote 99%, **95% confidence levels; values in brackets are SE.

| Household group                          | Sample size (n) | Below USD 1.90 per day | Below USD 3.10 per day |
|------------------------------------------|-----------------|-------------------------|------------------------|
| Protected area-adjacent (within 5 km)     | 230 (54%)       | 135 (59%)               | 175 (76%)              |
| Distant (5–25 km)                        | 193 (46%)       | 129 (66%)               | 164 (85%)              |
| Total                                    | 423 (100%)      | 264 (62%)               | 339 (80%)              |
TABLE 4 Results of ordinary least-squares regression analyses that tested the effects of Maasai Mara National Reserve, social, demographic, and geographical factors on the depth of poverty

| Variable | Income gap ratio at 1.90 USD | Income gap ratio squared |
|----------|-----------------------------|-------------------------|
| Distance from protected area boundary | −0.030 (0.031) | −0.025 (0.026) |
| Age of household head | −0.003 (0.008) | −0.004 (0.007) |
| Age of household head squared | 0.000 (0.000) | 0.000 (0.000) |
| Sex of household head | −0.011 (0.176) | −0.083 (0.147) |
| Education of household head (level 1) | −0.028 (0.039) | −0.004 (0.033) |
| Education of household head (level 2) | −0.013 (0.051) | −0.002 (0.043) |
| Education of household head (level 3) | −0.203 (0.085)** | −0.123 (0.071)* |
| Family size | 0.076 (0.048) | 0.033 (0.040) |
| Family size squared | −0.004 (0.004) | −0.001 (0.003) |
| Dependency ratio | 0.055 (0.026)** | 0.045 (0.021)** |
| Log landholding size | −0.044 (0.021)** | −0.038 (0.017)** |
| Kimintet | 0.102 (0.066) | 0.100 (0.055)* |
| Logorian | 0.007 (0.049) | 0.022 (0.041) |
| Mara | −0.029 (0.073) | −0.008 (0.062) |
| Naikarra | 0.103 (0.063) | 0.077 (0.053) |
| Siana | 0.177 (0.071)** | 0.140 (0.060)** |
| Crops | −0.051 (0.039) | −0.048 (0.033) |
| Employment | −0.190 (0.039)** | −0.145 (0.032)** |
| Benefits from protected area | −0.017 (0.018) | −0.014 (0.015) |
| Land contracting for wildlife conservation | 0.096 (0.050)* | 0.069 (0.041)* |
| Constant | 0.212 (0.264) | 0.299 (0.221) |
| $R^2$ | 0.24 | 0.20 |
| N | 391 | 391 |

Note: ***denote 99%, **95%, and *90% confidence levels; values in brackets are SE.

income gap from the poverty line. In contrast, an increase in the number of dependents was associated with an increase in poverty gap. Households that lived in Siana ward had, on average, 17.7% higher poverty gap index than households in the other wards. Participation in contractual wildlife conservation increased poverty gap marginally.

4 | DISCUSSION

The relative proportion of benefits gained, and losses incurred, by local people in relation to a protected area has important implications for biodiversity conservation and livelihoods. To contribute towards resolving the paucity of econometric evidence on the effects of protected areas on well-being of local people (McKinnon et al., 2016), the present study estimated the effects of Maasai Mara National Reserve on welfare and poverty statuses of local pastoral households. The study also assessed attitudes of the local households towards the protected area. We estimated the effect of proximity to the protected area along with effects of other factors on household welfare (indicated by income, assets and consumption expenditure), depth of poverty, and economic losses due to crop destruction and livestock depredation by wildlife from the reserve. Although our analyses are based on self-reported cross-sectional data (i.e. a snapshot in time analysis), the results suggest that Maasai Mara National Reserve did not have a statistically significant effect on welfare of the households, as measured by annual income, assets, per capita household expenditures, and depth of poverty. Households that lived adjacent to the protected area incurred greater economic losses caused by wildlife than distant households. Nevertheless, majority of the households held positive views about the protected area due to its conservation role and the benefits that they had already gained or expected to gain from it in the future.

Our study improves on previous quantitative estimates of socio-economic impacts of protected areas on pastoral households because we controlled for confounding effects of geographical characteristics in the statistical analysis. Many protected areas were purposely established in remote regions with pre-existing high levels of poverty (Miranda, Corral, Blackman, Asner, & Lima, 2016). While some protected areas did not have significant impacts on pre-existing poverty levels (Hanauer & Canavire-Bacarreza, 2015; Miranda et al., 2016), others exacerbated (e.g. Sherbinin, 2008; Vedeld, Jumane, Wapalila, & Songorwa, 2012) or reduced (e.g. Andam et al., 2010; Braber, Evans, & Oldekop, 2018; Hanauer & Canavire-Bacarreza, 2015) poverty. Variation in the direction and magnitude of protected areas’ effects on poverty has partly been attributed to the failure of many studies to control for observable confounding variables including geographical and baseline characteristics (Andam et al., 2010; Braber et al., 2018). For instance, in Cambodia, households that lived inside protected areas had lower access to markets and social services, and hence were poorer than households that lived in buffer zones (Clements et al., 2014). However, an analysis that controlled for confounding geographical characteristics by comparing a sample of households in similarly remote sites found that households that lived inside the protected areas were better off than households outside the park because of better and more secure access to land (Clements et al., 2014). In the present study, we controlled for confounding effects through a quasi-experimental design in which we collected socio-economic data from protected area-adjacent households (equivalent to a treatment group) and distant households (equivalent to a control group) and then employed entropy balancing to control for pre-existing differences between the two groups of households. Entropy balancing is a statistical correction technique that ensures similar distributions of covariates in treatment and control groups (also known as covariate balancing), thereby removing observable sources of bias (Hainmueller, 2012; Hainmueller & Yiqing, 2013). Analyses that aim to establish a link between protected areas and poverty should control for confounding variables...
to avoid conflating socio-economic effects of protected areas with the effects of pre-existing characteristics of the land on which protected areas are established.

4.1 | Factors other than Maasai Mara National Reserve were significantly associated with welfare and poverty statuses of the households

Factors other than Maasai Mara National Reserve were significantly associated with welfare and poverty statuses of the households (Table 1). Significant variation in per capita expenditure was observed among the six wards that we surveyed, which could be due to variation among the wards in factors such as soil quality, availability of water for livestock and human use, access to market, roads and other infrastructure around the protected area. Results of previous studies suggest significant correlations between these factors and welfare and poverty statuses (Biyase & Zwane, 2018; Okwi et al., 2007). We found that households in wards with a lower welfare status experienced significantly lower economic costs of crop raiding and livestock depredation than households in the reference ward (Angata Barikoi), regardless of proximity to the protected area (Table 1). It is plausible that households in wards with lower welfare owned smaller livestock herd sizes and areas of land under crop cultivation, and hence the proportionately lower costs of livestock depredation and crop raiding.

Education level of a household head and access to employment opportunities had significantly positive associations with household income and value of assets owned (Table 1). This finding supports results from studies elsewhere including South Africa (Biyase & Zwane, 2018), Botswana (Lekobane & Seleka, 2017), Ethiopia (Shete, 2010) and Nigeria (Edoumiekum, Karimo, & Tombofa, 2013). In our study, a household headed by a person who had attained post-secondary school level education had 66% more income than a household headed by a person who did not attain formal education at all. The educated household heads and some members of their households earned income from formal employment in various trades and professions (employed as a forest guard, teacher, mechanic, accountant, police officer, driver, doctor, tour guide, chef, clerk, engineer, game ranger, electrician, and military officer) that required people with competence acquired through post-secondary school training. Hence, it is likely that secondary school graduates were not as successful in securing formal employment as those who attained post-secondary school education (Table 1). Our results also show that landholding size had a significant impact on annual income of the households. This supports a prediction of economic theory that natural capital such as land is an important determinant of welfare and economic development (Jena, Chichaibelu, Stellmacher, & Grote, 2012; Shete, 2010).

Households that had contracted land for wildlife conservation (i.e. were members of wildlife conservancies) had less income and incurred greater economic losses due to livestock depredation and crop raiding than households that did not belong to any conservancy (Table 1). A separate study on wildlife conservancies around the reserve found that although income from contractual wildlife conservation was an extra source of income to households, conservancies imposed restrictions on traditional pastoralist livelihood activities such as livestock mobility in search of pasture and water (Oduor, 2020). By imposing such restrictions, conservancies might reduce livestock productivity. Moreover, contracting land for conservation also meant increased contact between wildlife and livestock, and hence increased costs of livestock depredation (Oduor, 2020).

Education level of a household head and the number of household members in formal employment significantly reduced income gap from the poverty line (Table 4). Other studies have found similar results (e.g. Akerele & Adewuyi, 2011; Gounder, 2013; Lekobane & Seleka, 2017). In contrast, an increase in the number of dependent household members (i.e. dependency ratio) was correlated positively with a significant increase in poverty gap (Table 4), which supports the widely held view that larger families tend to be poorer (Lanjouw & Ravallion, 1995). Empirical analyses suggest that the larger the household size, the higher is the likelihood of falling among the poor, because more resources are required to meet basic needs of the household members (Amara & Jemmali, 2018; Lanjouw & Ravallion, 1995). In the present study, households that lived in Kimintet and Siana wards experienced large poverty gaps (Table 4). It is likely that in these wards, factors associated with poverty such as limited access to education and employment opportunities were more rampant than in the other wards that we surveyed. However, living close to the protected area was not associated with poverty gap (Table 4).

4.2 | Protected area-adjacent households incurred greater economic costs of wildlife destruction than distant households

Households that lived adjacent to Maasai Mara National Reserve incurred significantly higher economic costs due to crop raiding and livestock depredation than distant households, while the two groups of households did not differ from each other significantly in welfare measures (Tables 1 and 2). These results suggest that protected area-adjacent households would have significantly higher welfare than distant households in the absence of crop raiding and livestock depredation losses. It is likely that the protected area-adjacent households had access to income opportunities that were otherwise unavailable to distant households, which could have improved welfare status of the former. Indeed, anecdotal observations that we made during field data collection suggested that some households that lived at the edge of the protected area received monetary gifts from tourists that visited their homes to appreciate their traditional way of life. It is possible that the protected area-adjacent households did not report these during the interviews because they might not consider them as a source of regular income. A similar observation was made in Uganda where households that lived within 0.5 km of Kibale National Park boundary incurred greater losses (Mackenzie, 2012) but also earned greater benefits from illegal access to park resources than distant households (Naughton-Treves, Alix-Garcia, & Chapman, 2011).
Our results support those of other studies, which found that protected area-adjacent households incurred various costs attributable to wildlife including wildlife attacks on humans that resulted in human injury or death, crop raiding, livestock depredation, and property damage (e.g., Gadd, 2005; Owino et al., 2012).

Negative impacts of protected areas on local people’s livelihoods may result in social discomfort to the people and weaken their support for conservation. Therefore, in our case, protected area-adjacent households that incurred larger conservation costs need support to limit losses caused by wildlife. A study found that solar-powered LED flashlights that were installed around cattle pens reduced significantly nocturnal depredation on cattle by lion (Panthera leo) around Nairobi National Park in Kenya (Lesilau et al., 2018). People living around Maasai Mara National Reserve may adopt such a piece of technology. The people may also install solar-powered electric fences around cattle pens. In addition, high-risk villages and households may be educated on how to prevent and mitigate conflict with wildlife.

4.3 | Majority of the respondents held positive attitudes towards Maasai Mara National Reserve

Eighty-six per cent of the respondents supported the existence of Maasai Mara National Reserve due to the benefits that they had already obtained from tourism activities related to the protected area, their enthusiasm for biodiversity conservation, and greater benefits that they hoped to gain from the protected area in the future. A similar level of support was reported for households that lived around Oldoinyo Sapuk National Park in central Kenya where 85% of the respondents were in favour of the existence of the park (Owino et al., 2012). Positive attitudes of the locals towards protected areas are crucial for long-term viability of the protected areas as the locals may shun vengeance killings of wildlife and report poaching activities to the authorities.

4.4 | Limitations of the present study

Results of the present study are based on cross-sectional data. However, because the impacts of a protected area can be influenced by how long it has existed (Gurney et al., 2014), a comprehensive understanding of the socio-economic impacts of a protected area requires a longitudinal analysis in which impacts of a protected area are assessed at multiple time points (Gurney et al., 2014). The present results may thus be used as a baseline for future evaluations of socio-economic impacts of Maasai Mara National Reserve. Moreover, our analyses relied upon individual interviewee’s recall and self-reported costs of crop raiding and livestock predation by wildlife from the reserve, which raises the possibilities of exaggeration of losses incurred (although our results do not have any indication of a systematic bias across the households we surveyed). To complement the present findings and provide a more robust assessment of conflicts between human and wildlife in the study area, a systematic location-based monitoring that records information on conflict as it happens would be needed.

We assessed impacts of Maasai Mara National Reserve based on externally defined material aspects of well-being (income, assets, and consumption expenditure), which may not necessarily reflect local people’s priorities. Human well-being is a broad term with multiple meanings, but there is increasing agreement in international policy circles that it encompasses objective material circumstances of people’s lives (i.e., basic human needs, economic well-being, and environmental well-being), relational aspects, and a subjective component capturing an individual’s assessment of their own circumstances (Summers, Smith, Case, & Linthurst, 2012; Woodhouse et al., 2015). Thus, a broad set of externally verifiable quantitative indicators and perceived changes by local people reflecting the subjective aspect of well-being allows for more accurate assessments of the impacts of protected areas than indicators that focus on single components (Woodhouse et al., 2015). It is imperative that future studies that aim to understand the impacts of Maasai Mara National Reserve on the multiple dimensions of local people’s well-being adopt a mixed-methods approach incorporating quantitative and qualitative (i.e., feelings and perceptions) assessments of well-being. As different people perceive well-being and are impacted in different ways, heterogeneity may exist within a household, for example across gender and age groups (de Lange, Woodhouse, & Milner-Gulland, 2016). Future studies should capture this heterogeneity through sampling individuals besides the household averages. This would enable distributional dimensions of equity to be captured (Daw, Brown, Rosendo, & Pomeroy, 2011). Similarly, impacts are manifested heterogeneously within a community (de Lange et al., 2016). Thus, future studies should also sample different subgroups (e.g., livelihoods and social statuses) within the community living around the reserve.

5 | CONCLUSION

In this paper, we applied econometric approaches to assess socio-economic impacts of Maasai Mara National Reserve on local pastoral households. We also assessed attitudes of the households towards the protected area. Less than half (43%) of the respondents stated that they benefitted from tourism and businesses related to the reserve, while 80% of respondents had incurred economic costs related to crop destruction and livestock depredation by wildlife from the reserve. Nevertheless, majority of the households (86%) held positive views about the protected area due to benefits that they had already gained and expected to gain from it in the future, and their enthusiasm for biodiversity conservation. Because a large proportion (62%) of the households that we surveyed lived below poverty line (less than USD 1.90 per day) and the protected area had limited positive impact on welfare of the local households, we suggest that interventions should be deployed to help local households
obtain greater benefits from the protected area and alleviate poverty in the locality. To reduce poverty and promote local people's welfare, policies that would promote employment opportunities, educational status of household heads and regulate family size should be implemented. During the interviews, some households called for management authority of Maasai Mara National Reserve to compensate them for livestock and crop losses caused by wildlife. However, compensation schemes are fraught with many challenges including having to: (a) guard against fraudulent claims, (b) ascertain that damage was caused by a park-protected animal, and (c) guard against situations whereby local people fail to protect their property because there will be compensation anyway. Given the challenges of implementing compensation, we advocate that any resource that may be made available to limit damage by wildlife from the reserve should be applied to the development of better livestock and crop protection.

ACKNOWLEDGEMENTS

We thank two anonymous reviewers and the editors for constructive comments on previous versions of the manuscript. This study was funded by a grant from the National Natural Science Foundation of China (NSFC) to Linxiu Zhang (no. 31361140360), and post-doctoral research fellowships of the Chinese Academy of Sciences President's International Fellowship Initiative (CAS-PIFI) to A.M.O. Oduor (no. 2016PE016) and Dagne Mojo (no. 2017PC0067). The funders had no role in the study design, data collection, and manuscript writing. We thank all the villagers who participated in the study and the following field research assistants for help with data collection: Dominic Leina, Daniel Sabore, Joel Tolian, Daniel Mokita, Musa Mainoya, Joshua Ketuyio, Mathew Sayianka, Saitoti Lemashon, and Alex Oloitipitip.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS’ CONTRIBUTIONS

A.M.O.O. conceived the research idea, designed the research, and collected the data; D.M. performed statistical analyses; A.M.O.O. and D.M. drafted the manuscript; C.F., Y.B., H.L., G.W. and L.Z. contributed to a revision of the manuscript and approved of the final version for submission.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study have been deposited in a Dryad Digital Repository with https://doi.org/10.5061/dryad.89312crn6 (Oduor et al., 2020).

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ENDNOTES

1 A tropical livestock unit is calculated based on individual counts of cattle, sheep and goats owned. Conversion factors used are 0.7 and 0.1 for cattle and sheep/goats, respectively (Jahnik, 1982).

2 The results on the detailed composition of household income and costs are not displayed in Table S1.

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**SUPPORTING INFORMATION**

Additional supporting information may be found online in the Supporting Information section.

**How to cite this article:** Mojo D, Oduor AMO, Fu C, et al. Effects of protected areas on welfare of local households: The case of Maasai Mara National Reserve in Kenya. *People Nat.* 2020;2:856–867. https://doi.org/10.1002/pan3.10123