Evaluating the management effectiveness of nature reserves by using WWF's management effectiveness tracking tool (RAPPAM)

A case study from the Sultanate of Oman

Majid Alkhanbashi[*], Fang Ping[**]

[*] Tongji University, UNEP Institute of Environment for Sustainable Development (IESD): College of Environmental Science and Engineering, Shanghai 200092, P. R. China.
[**] State Key Laboratory of Pollution Control and Resource Reuse, College of Environmental Science and Engineering, Tongji University, Shanghai 200092, P. R. China.

Abstract

The increase of nature reserve areas in the country is Insufficient to conserve biodiversity. The study aims to evaluate the management effectiveness of seven nature reserves in the Sultanate of Oman. The study used the Rapid Assessment and Prioritization of Protected Area Management Methodology (RAPPAM) tool. The tool examines the management cycle elements of the nature reserve includes; context, planning, input, process, and outputs. Also, the tool is used to evaluate the pressures and threats that nature reserves suffer from. The data gathered from different recourses include workshops, nature reserves data, and stakeholders meetings. The results indicate that hunting is significant pressure for terrestrial reserves and fishing nets are the main pressure. these pressures will continue affecting reserves in the future. the management effectiveness of the seven nature reserves was at the basic level of management requirements. The reserve has long-term legal security, clear conservation goals and policies, and stable government funding. The management challenges were design planning, financial management, quantitative and qualitative of human resources, standards and guidelines, monitoring, and data availability. Oman nature reserves require improvement in management plans, establish capacity building programs, sustainable funding, set standards and clear procedures in nature reserve operations, improvement of stakeholders and community engagement, provide nature reserves with quantitive and qualitative human resources.

Keywords; management effectiveness, nature reserves, management planning, pressure, and threat analyses

1. Introduction

Nature reserves are important for conserving biodiversity and ecosystems [1]. They maintain natural and culturally significant features on national and global scales. The International Union of Conservation of Nature defined nature reserves as '' is a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" [2]. Protected areas worldwide have different goals contributing to conserving important species, providing environmental services, and enhancing local communities' well-being through effective management [3]. In addition, protected areas have objectives to ensure that all-natural and social values have taken into account. Aichi Target 11 determined six elements of nature reserves including, the importance for biodiversity and ecosystem services, biological connectivity, the management is equitable, effective management, integrated with wider land-seascape, and biologically representative [4]. In December 2022 in Montreal, Canada, (COP 15) global parties agreed new agenda for 2030 to protect biodiversity [5]. The new agenda in protecting diversity is listed in target1,2,3,4. The target which is related to nature reserves and conservation areas is Target 3. By 2030, 30% of global land and sea areas are conserved through effective practices [6]. According to the protected planet database on January 2023 updated data, there were 285,529 protected areas recorded [7]. There were 267,085 nature reserves covering 15.8 % of global terrestrial and inland waters. Also, there were 18,444 marine nature reserves representing 8.16 % of global marine areas (Figure *1*).
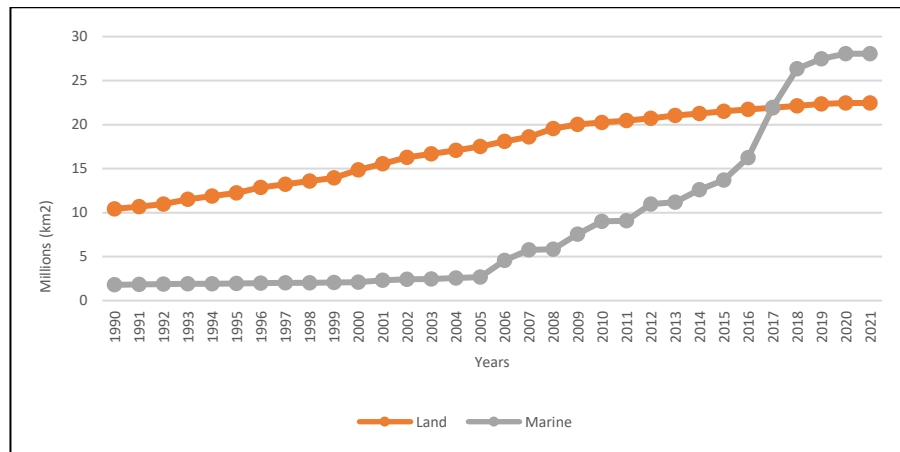
Figure 1; Global Nature reserves areas between 1990 – 2021 [7]

Therefore, the Sultanate of Oman is one of the countries which agreed on the CBD convention and established nature reserves to meet the Aichi target. The Sultanate has a unique environment that represents a natural heritage. Since 1975 sultanate of Oman has been one of the countries that started planning and managing protected areas [8]. Today there are 26 protected areas managed by the Environment Authority [9]. All protected areas are symbolized the country's ecosystems, such as mountain deserts and marine ecosystems [10]. The table below presents the protected areas in Oman; The Sultanate has 26 nature reserves with a total area of 15526.7 km^2. The terrestrial and inland waters nature reserves cover 13364.8 km^2, representing 4.32% country area. The marine nature reserves cover 2161.9 km^2, with 0.32 % of the Exclusive Economic Zone.

Despite the rise of nature reserves for biodiversity conservation, they need to know in which manner the NRs manage, as well as the effective management of NRs. Because even the management plan of NRs implemented, the results of conserving species only succeed in some cases. The species are still decreasing, and ecosystems are subject to fragmentation. Protected areas face more issues from different activities. Responding to these problems is vital to ensure nature conservation, but usually, it takes a lot of work for NRs managers. Also, they need to track the achievement of goals and evaluate actions. On the other side, stockholders and the local communities need NRs managers to be more transparent [11].

Thirty years ago, NRs experts developed and applied a series of methods in NRs management effectiveness tools at different management levels [7]. The methodologies have a variety of contents but all have three main evaluation components. IUCN World Commission on Protected Areas (WCPA) established protected areas management effectiveness (PAME) framework. Since then, the methodologies have been applied as appropriate tools to evaluate and track management effectiveness [12]. There are more than 50 effective management tracking tools [13].

One of the early examples of protected areas assessment was established in 1995 by World Commission on Protected Areas (WCPA) after the fourth of the IUCN World Park Congress [13]. They assigned a team to study protected areas' management effectiveness issues [14]. The result of the team was the framework of management effectiveness assessment. The framework formed an approach for evaluating the protected areas management effectiveness (PAME). One of the important tools used to assess the effectiveness of protected areas management is Rapid Assessment and Prioritization of Protected Area Management (RAPPAM) [15] which was developed by the International Union for Conservation of Nature (IUCN) World Commission on Protected Areas IUCN-WCPA Framework and funded by World Wildlife Fund (WWF) [16].

The first management effectiveness evaluation in the Sultanate of Oman was conducted in 2006 by IUCN experts. The report assessed management effectiveness for six protected areas in the country [17]. In that report, they used PA Tracking Tool (PATT) based on the WCPA Protected Areas Management Assessment framework. It has 30 assessment questions in different NRs management cycle elements [17]. The tool was developed by experts from different agencies such as IUCN and WWF. The evaluation of the tool focuses on the elements of the management system; context, planning, input, process, output, and outcomes. They used data, management plans of protected areas, and workshops to conduct the assessment [17].

The report described and assessed the management system for all protected areas. In the **context,** protected areas had a legal cover by the Royal Decree No. 6, 2003 (Law on Nature Reserves and Wildlife Conservation) [10]. Also, the regulations of protected areas were still under development. In addition, law enforcement was the main challenge in protected areas, especially in the reserves which have large areas such as Jabal Samhan Reserve and Arabian Oryx Sanctuary (Al Wusta Wildlife Reserve) [17].

In the planning phase, most of the protected area staff did not have clear objectives in the management plan and the goals were general. The weakness of implemented management plan because of many reasons for applying the management plan such as; there was limited participation from stakeholders and reserves staff, the management plans developed by international experts and the management plan prepared without baseline assessment of natural resources [17].

In the input phase, there were limitations in biodiversity assessment, collection, and research in most of the protected areas. All data collected from the site were unable to use by NRs managers and were not effective. Also, the quantity and quality of staff training did

not meet the needs of NRs management. In addition, the NRs budget support only the basic NRs operation activities such as law enforcement and patrolling [17].

In the process phase, the management of NRs in Oman recognized the "top-bottom" approach. That affected participation of the local community in NRs management. The education and awareness of local community involvement were at a low level. Also, there were limitations in patrolling law enforcement and research in the reserves [17]. There was a limitation in local community wellbeing programs in outputs as well as visitor facilities in reserves compared with the number of visitors. Some restoration activities were held in reserves, such as turtle monitoring, Oryx breeding center, and mangrove replanted projects, but other NRs still need more activities to enhance biodiversity management [17].

In 2009 experts from National Parks Services and Fish and Wildlife Service conducted a technical report about Al Diymaniyat Islands Nature Reserve and Turtles Reserve. The experts used Management Effectiveness Tracking Tool (METT) to evaluate the effective management of the reserves [18]. One of the main issues recorded was the low capacity building of the staff and equipment support. Also, there were different human activities that conflicted with the purpose of establishing protected areas. In addition, there was limited communication with local communities and main stakeholders. The education and awareness programs did not meet the ambitions. All management plans did not have actions and the monitoring programs focused only on turtles in Turtles Reserves [18]. The report draws various recommendations to enhance the management of Al Diymaniyat Islands Nature Reserve and Turtles Reserve such as developing cooperation with government stakeholders, private sectors, and Non-governmental organizations (NGOs). Also, improve staff capacity building and give them clear responsibilities [18]. In 2012 they assessed Al Wusta Wildlife Reserve and the Jabal Samhan Reserve. They also used METT tool. Al Wusta Wildlife Reserve faced a series of problems in its management practices. Poaching, gazing, and un updated management plan were the major issues in the reserve [19]. Also, the reserve had a lack of biodiversity and other important features data as well as no educational and awareness programs for the reserve visitors [19]. The other reserve which was Jabal Reserve also faced the same issues. In addition, the reserve did not have good communication with the local community and main stakeholders. The staff and equipment did not reflect the size of the reserve which is 4500 km^2 [19]. This study aims to assess the management effectiveness of seven nature reserves in the Sultanate of Oman using RAPPAM, a tool (Rapid Assessment and Prioritization of Protected Area Management Methodology), and establish baseline data and information for future studies and assessments.

2. Methodology
2.1. Study area

The study of Rapid Assessment and Prioritization of Protected Area Management will focus on seven NRs in the sultanate of Oman under the Environment Authority. The reserves are a model of various ecosystems in the country and distribute in several governorates. The table (Table 1) and (Map 1) below present the targeted NRs.

Table 1: Nature reserves assessment cases [10]

English Name	IUCN category	Areas km2	Year
Qurm Nature Reserve	IV	1.7	1975
Al Wusta Wildlife Reserve	IV	2824.3	1994
Al Diymaniyat Islands Nature Reserve	IV	203.0	1996
Turtles Reserve	IV	120.0	1996
Jabal Samhan Reserve	IV	4500.0	1997
As Silil Natural Park	IV	220.0	1997
Jabal Qahwan Nature Reserve	Ib	289.6	2014
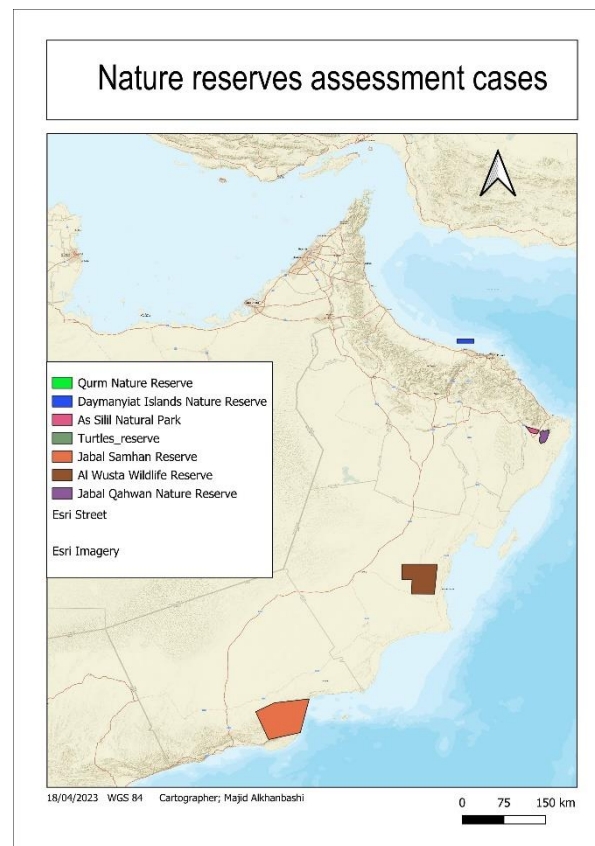
Map 1: Nature reserves assessment cases [20]

2.2. RAPPAM tool

The assessment of the RAPPAM tool is based on the management cycle of NRs [16]. The evaluation tool focus on management cycle elements including; context, planning, inputs, processes, outputs, and outcomes. The tool consists of multiple questions and required information [14]. The six elements of NRs management cycle are important to conduct an assessment because they explain how the management plan work [16].

Assessed pressures and threats in the RAPPAM tool are the main element of the evaluation to understand nature reserve status. Pressures are activities that impact on NRs ecological elements. Threats are expected activities that will harm NRs natural features This stage explains what kind of pressures affect nature reserve including; activity status, extent range, degree of impact and permanence. Also predicts the threats in the future including; status, extent range, degree of impact, and permanence [14]. The scoring method of pressures and threats are presented in (Table 6) below;

Table 2: The scoring method of pressures and threats [14]

Pressures and Threats scores		
extent	impact	permanence
Throughout = 4	Sever = 4	Permanent = 4
Widespread =3	High = 3	Long term = 3
Scattered = 2	Moderate = 2	Medium term = 2
Localized = 1	Mild = 1	Short term = 1

The range of the pressures and threats are between 0 and 64 divided into four levels; Sever (>48), high (32-48), moderate (16-32), and mild (1-16) (Junior et al., 2020).

$$\text{Pressure/Threat} = \text{extent} \times \text{impact} \times \text{permanence}$$

The context assessment focuses on the ecological values of the reserve including rare, threatened, endangered species, high levels of endemic species, biodiversity, landscapes function key species, ecosystems, and the changes over time. Also, the socio-economic part includes; employment, subsistence, community development opportunities, the socio-economic importance of plants and species, the religious importance of the reserve, ecosystem services, or educational/ scientific value [21]. In addition, vulnerability evaluate; Illegal

activity monitoring, law enforcement, bribery, political instability, conflicting traditional use, Market value, accessibility, resources demand, political, and economic pressures, and keeping staff [14]. The range scores of the first stage assessment are between 5 and 0, which indicate high and low importance (WWF Gland, 2003). The total score of each part of the context; ecological, socioeconomic and vulnerability is 50 and the range of each question is between 5 to 0 (5 yes, 3 mostly yes, 1 mostly no, 0 no), which reflects the value [14].

The second stage is to evaluate the management cycle system, which include; planning, input, process, output and outcomes. All management cycle elements represent the effectiveness of nature reserve management [21]. Planning includes; objectives, legal security, site design and planning. Inputs include; human resources, communication, information, infrastructure, and budget. Processes contain; management planning, management decision planning, research, monitoring and evaluation. Outputs include; preventing threats, site restoration, wildlife management, community outreach, visitor's management, infrastructural development, planning, inventorying, staff monitoring, training & development and research outputs [14]. In questions of effective management evaluation, the range of scores also between 5 to 0 (5 yes, 3 mostly yes, 1 mostly no, 0 no), which reflects values. In management effectiveness scores we are going to use Leverington and others method [22]. The score range will be from 0 to 1 (1 yes, 0.67 mostly yes, 0.33 mostly no, 0 no) to make it easy to compare between evaluation elements and other cases.

3.   Result
3.1. Pressures and threats

From the results of conducting RAPPM tool to assess pressures and threats from 2018 to 2022, the reserves were under a series of pressures. These depend on the type of nature reserves; marine or terrestrial NRs. The pressures that impact NRs are; fishing nets, sink ships, divers stress, littering, hunting, wood cutting, grazing, pasture competition, oil and gas exploration projects, collecting frankincense, fishing, development, invasive species, lightning, car access, turtles' accidents by boats, using turtles for food, camping, visitors disturbance, and gas pipe project. The result scores ranged between (78 - 201) for pressures and (130 – 231) for threats.

The major pressures on reserves are hunting 13.6 %, roads 10.8 %, fishing nets 10.1 %, grazing 9.7%, oil and gas exploration 8.7%. Table (Table 3) illustrates the degree of pressures (0 - 64) in NRs includes; fishing nets 1, sunken ships 2, divers stress 3, littering 4, hunting 5, wood cutting 6, grazing 7, pasture competition 8, roads 9, exploration projects 10, collecting frankincense 11, fishing 12, *Sesuvium portulacastrum* 13, *Prosopis juliflora* 14, lightning 15, urban development 16, car access 17, turtles accidents 18, turtles for food 19, camping 20, visitors disturbance 21, gas pipe project 22. Fishing nets (DIR and TR), grazing in JSR, roads (ASNP and JSR), exploration projects (WWR and JSR), collecting frankincense (JSR), *Prosopis juliflora* (QNR) and gas pipe project (ASNP) categorized as a high degree of pressures. Pressures of sink ships (DIR), divers stress (DIR), hunting (ASNP, JQNR, WWR and JSR), wood cutting (ASNP and JSR), grazing (ASNP and JQNR), pasture competition (JQNR), roads (WWR), *Sesuvium portulacastrum* (QNR), lightning (TR), car access (TR) categorized as moderate. The mild degree of pressures are littering (DIR and QNR), wood cutting (JQNR), fishing (QNR), turtles accidents (TR), turtles for food (TR), camping (TR), visitors disturbance (TR).

Totally, JSR recorded the highest-pressure scores (201), then TR with (166), next ASNP with (156), after that DIR (105), then WWR (81), next JQNR (80), finally QNR (78) (Figure 2).
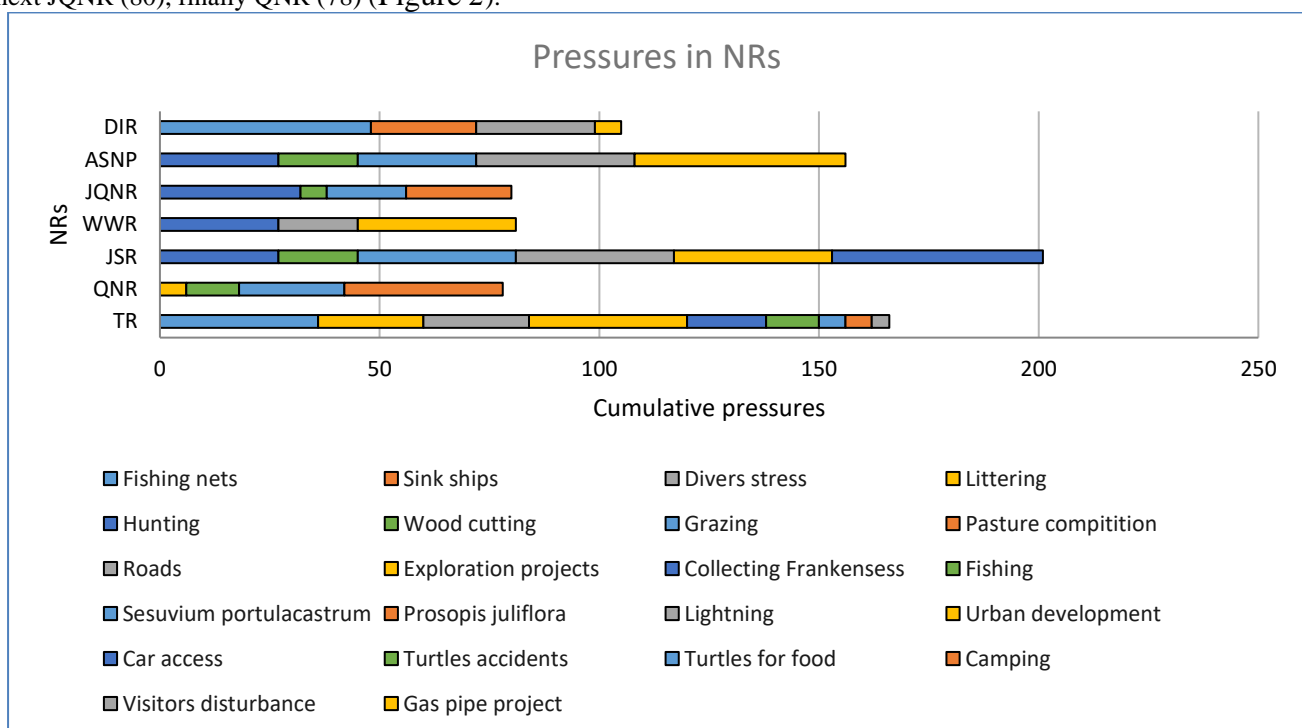

Figure 2: Total Pressures in NRs

The threats analysis is a main part of RAPPAM assessment. There are many threats expected in the future that will negatively affect biodiversity in NRs. The cumulative impacts of pressures in the future will set the reserve under high risk. The forecast of some pressures shows they will decline in the future. () illustrate the expected threats in NRs. The expectation of hunting 10.3%, fishing nets 8%, grazing 7.8%, and roads 7.5% will continue to affect NRs in the future and will be the main threats. The other threats will depend on the certain reserve.

Table (Table 4) predicts the future threats that will affect NRs. The threats of Prosopis juliflora 18, classified as a severe threat in QNR. Fishing nets 1 (DIR and TR), divers stress 3 (DIR), hunting 6 (WWR and JSR), oil and gas exploration projects 12 (WWR and JSR), collection of frankincense 13 (JSR), fishing 15 (QNR), development 16 (QNR and TR), Sesuvium portulacastrum 17 (QNR), lightning 19 (TR) and gas pipe project 25 will be at high degree.

The threats, Sunken ship 2 (DIR), resort development 5 (DIR), hunting 6 (ASNP and JQNR), wood cutting 7 (ASNP and JSR), grazing 8 (ASNP, WWR and JSR), pasture competition 9 (JQNR), roads 10 (ASNP, JQNR, WWR and JSR), mining 11 (JQNR, WWR and JSR) and visitors disturbance 23 (TR) will be at a moderate level. The littering 4 (DIR) , camping 20 (TR), turtles accidents 21 (TR), turtles for food 22 (TR) car access 24 (TR), and tourism activities 14 (ASNP, WWR and JSR) threats will be at a mild level. In the future, we expect that threats will increase in most NRs. in JSR will reach (231), TR (221), QNR (190), WWR (153), and JQNR (130). The threats in ASNP will decrease inconsiderably (153) (Figure 3) (Table 4).
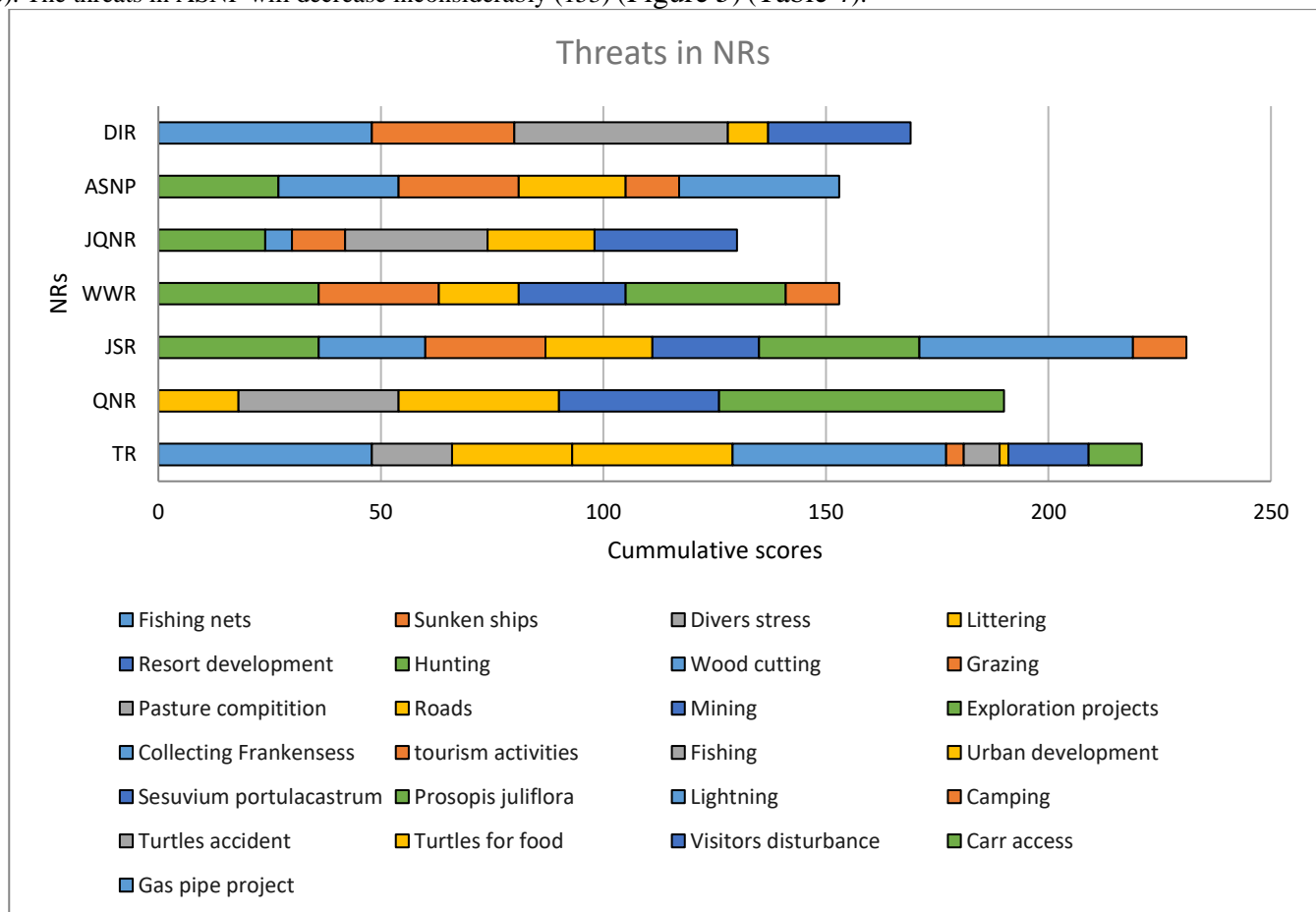

Figure 3: Total threats in NRs

Table 3: The degree of pressures in NRs

Reserve	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
DIR	48	24	27	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ASNP	0	0	0	0	27	18	27	0	36	0	0	0	0	0	0	0	0	0	0	0	0	48
JQNR	0	0	0	0	32	6	18	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WWR	0	0	0	0	27	0	0	0	18	36	0	0	0	0	0	0	0	0	0	0	0	0
JSR	0	0	0	0	27	18	36	0	36	36	48	0	0	0	0	0	0	0	0	0	0	0
QNR	0	0	0	6	0	0	0	0	0	0	0	12	24	36	0	0	0	0	0	0	0	0
TR	36	0	0	24	0	0	0	0	0	0	0				24	36	18	12	6	6	4	0

Severe		> 48		High		32 - 48		Moderate		16 - 32		Mild		< 16

Table 4: The degree of threats in NRs

Reserve	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
DIR	48	32	48	9	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ASNP	0	0	0	0	0	27	27	27	0	24	0	0	0	12	0	0	0	0	0	0	0	0	0	0	36
JQNR	0	0	0	0	0	24	6	12	32	24	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WWR	0	0	0	0	0	36	0	27	0	18	24	36	0	12	0	0	0	0	0	0	0	0	0	0	0
JSR	0	0	0	0	0	36	24	27	0	24	24	36	48	12	0	0	0	0	0	0	0	0	0	0	0
QNR	0	0	0	18	0	0	0	0	0	0	0	0	0	0	36	36	36	64	0	0	0	0	0	0	0
TR	48	0	18	27	0	0	0	0	0	0	0	0	0	0	0	36	0	0	48	4	8	2	18	12	0

Severe		> 48		High		32 - 48		Moderate		16 - 32		Mild		< 16

3.2. Context

the environmental significance of NRs showed positive results based on evaluation elements developed by the tool. JSR, take the head of all cases in ecological importance with (42) scores. In socio-economic importance, three cases of NRs have high scores such as; DIR (32), JSR (36), and TR (35). TR and JSR got the highest vulnerability score.

From data, management plans of nature reserves, and specialist's perception, JSR has the highest context score (102), then TR (88) after that, DIR (73). The lowest score was QNR with (56) points. The following (Table 5) and (Figure 4) summarize the main context elements and scores.

Table 5: NRs context scores

Row Labels	Ecological Importance	Socio-economic Importance	Vulnerability	Total
ASNP	26	19	13	58
DIR	30	32	11	73
JQNR	32	11	15	58
JSR	42	36	24	102
QNR	24	19	13	56
TR	29	35	24	88
WWR	29	20	5	54
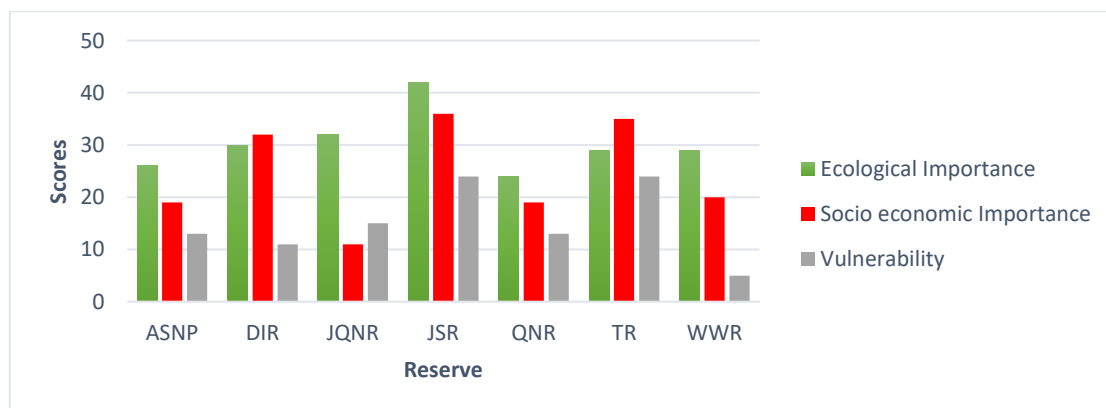
Figure 4: NRs context values

3.3. Management effectiveness

The total average management effectiveness of NRs cases was (0.43) All NRs have received basic management scores (0.33 – 0.49) which still need improvement. The results of seven NRs management effectiveness are as follows; DIR (0.46), ASNP (0.46), JQNR (0.33), WWR (0.47), JSR (0.38), QNR (0.40) and TR (0.48). TR and WWR received the highest score (0.48) and (0.47). DIR, ASNP, JSR and QNR scores are between (0.38) and (0.46). The lowest score is JQNR (0.33); (Table 6), (Figure 5).

Table 6: Management effectiveness scores of NRs

Reserve	Planning	Input	process	output
DIR	0.53	0.45	0.33	0.50
ASNP	0.51	0.48	0.35	0.50
JQNR	0.47	0.37	0.20	0.20
WWR	0.51	0.50	0.43	0.54
JSR	0.42	0.36	0.40	0.37
QNR	0.58	0.32	0.31	0.36
TR	0.53	0.49	0.44	0.57
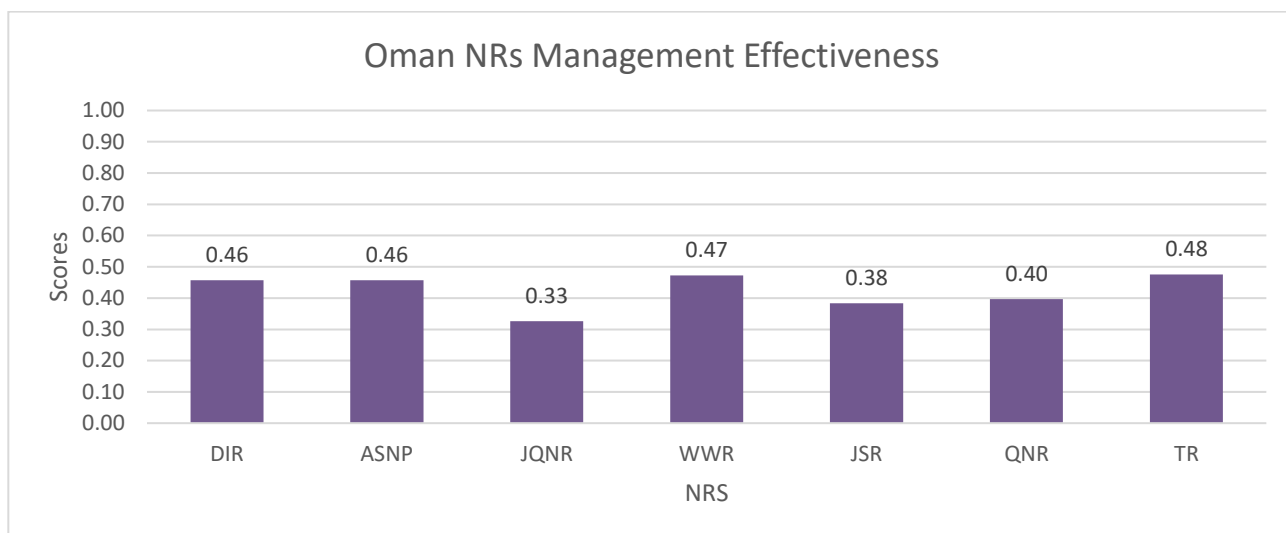
Figure 5: Management effectiveness values of NRs

From planning evaluation results are shown in (Figure 6**Error! Reference source not found.**). QNR has the highest score in the planning phase of NRs (0.58). The lowest planning scores are ASNP and JSR (0.44). DIR (0.53), TR (0.53), WWR (0.51), JQNR (0.49) are at medium scores.
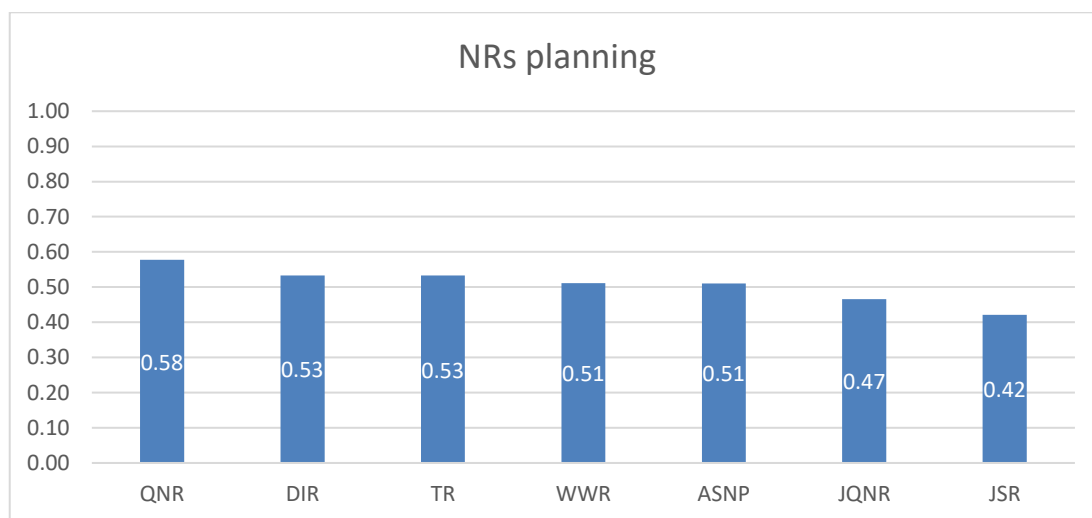
Figure 6: Planning phase values

The total average of input in all NRs was (0.44). Generally, NRs are at the basic level of the management input phase, but JQNR, JSR, and QNR are at the low level of the management input phase (Figure 7**Error! Reference source not found.**). ASNP received the highest score (0.52) due to budget performance and essential input in human resources, communication, and information, except infrastructure. WWR and TR got (0.50), considered slightly good primary input in communication, information, and infrastructure. DIR has (0.48) related to slightly low performance in Human resources and infrastructure. The insufficient inputs are in JSR (0.38), JQNR (0.35), and QNR (0.33). JSR and JQNR recorded the lowest score in infrastructure input (0.26) and (0.20). QNR is the weakest human resources score (0.07), close to zero.

Figure 7: NRs input phase values

The total average of NRs process score was (0.32) below the basic requirement level (Figure 35). Generally, there is no acceptable procedure or standard that NRs follow, which underscores the need to set a management standard. ($Figure\ 8$) below illustrates the process scores of each case.

Figure 8: NRs process phase scores

The total average of NRs output is (0.43) at the basic management achievement level ($Figure\ 9$). All NRs cases are between (0.20) and (0.57). TR received the highest score of output (0.57) due to high score in visitor management (1), prevent threats (0.67), site restoration (0.67) and community outreach (0.67), infrastructural development (0.67) and research outputs but it got low score in wildlife management, planning & inventorying, staff monitoring, training & development (0.33).
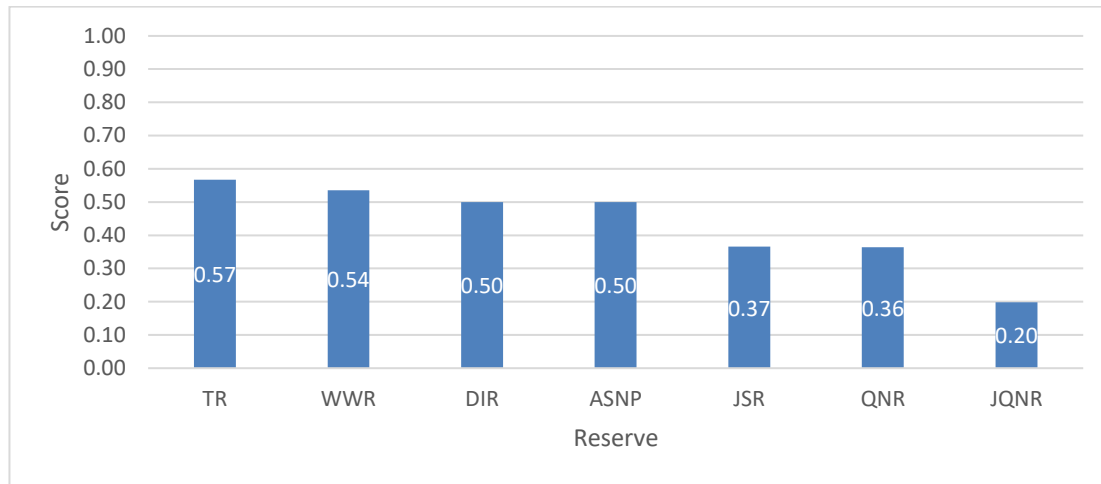
Figure 9: NRs outputs

4.   Discussion

4.1. Pressures and threats

RAPPAM tool includes one of the typical methods to analyze pressures and threats that did not discuss in previous studies in Oman. The method uses criteria that could help NRs managers to track the improvement or degradation of NR resources. The result of pressures on NRs represented the situation of NRs and the problems they faced from 2018 to 2022. Socioeconomic development affects the nature reserve through main drivers such as fishery sector development, urban development, industries, and human well-being. All terrestrial NRs including ASNP, JQNR, WWR, and JSR suffer from hunting which is the main pressure. Hunting represents 13.6% of NRs pressures. In [23] study, hunting also was the main pressure in Brazil but the reasons were trade market, recreation, and substance. In Oman, most hunting pressures are recreation while the significant pressures on the Serbian reserve were land use and harvesting of resources, water management, and unsettled ownership [24]. Hunting pressure will continue to affect terrestrial NRs. all marine NRs such as DIR, QNR, and TR are affected by fishing nets from local fishery activities. Fishing nets pressure represents 10.1% and that will increase in the future. All pressure and threats in NRs should be the priority in the NRs management plan. The correlation between pressures and the socioeconomic values of NRs in (Figure 10) presents highly positive (0.7).
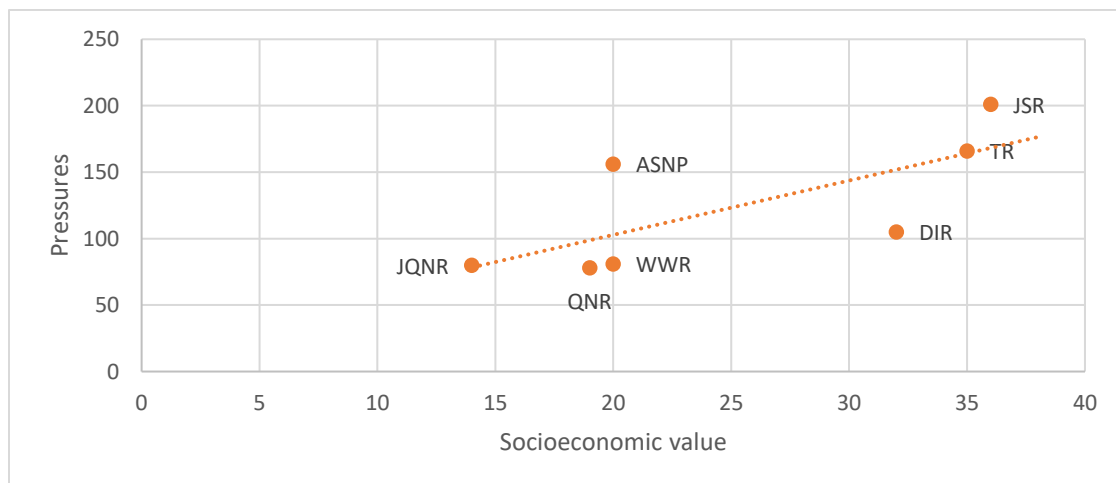
Figure 10: The Correlation assessment between Socioeconomic and Pressures in NRs

The location and the area of JSR make it under various industries pressures. The industries such as oil, gas, and minerals are working in progress to explore the main reservoirs, catchments, and aquifers. Strict management for the reserve depends on nature reserve zonation to mitigate the pressures. The reserve has a high score of pressures, and the expectation of pressures will increase. Minimizing collecting frankincense, exploration projects, hunting, and grazing pressures are priorities for NRs managers. In (Figure 10) demonstrates JSR has a high correlation between socioeconomic values and pressures in the reserve.

Lightning, fishing nets, and urban planning are TR's main pressures and threats, which need more efforts to mitigate the impact on turtles' beaches. Urban development and tourism activity in TR directly influence biodiversity, which explains the high correlation

between socioeconomic values and pressures (Figure *10*). The current situation in ASNP is at Pipeline risk, which is the main pressure and highly impacts wildlife. The project owner and contractor should implement the environmental management plan and mitigation action. In the future, the project should consider wildlife movement. Also, roads are the main pressure that should manage by ASNP management section.

In DIR, managers should consider fishing nets which are a result of fishing activities and as well as divers stress. These main pressures are priority actions for DIR management. QNR is under two main environmental pressures: *Sesuvium portulacastrum* and *Prosopis juliflora*. These invasive species will extend and affect native plants and reserve habitats without direct combat. JQNR is remote from urban development which has a low impact. The main pressure that should take priority in conservation management is hunting. In addition, the JQNR management should monitor the pasture competition between wildlife species and donkeys. Exploration projects and hunting in WWR are challenges that affect conservation efforts. The management should work with the main stakeholders to mitigate the impact of these pressures in the future. Grazing in the reserve was slightly decreased compared with [19] study because of WWR management instructions for livestock owners.

4.2. Context

Understanding NRs context is the first step to managing nature reserves. These elements explain the situation of ecological, socioeconomic, and vulnerability in NRs. The conservation approach should prioritize biodiversity hotspots and threatened species in NRs to ensure long-term conservation [4]. The comparison result of ecological values and vulnerability shows JSR, TR, and JQNR have the highest priority of conservation action (Figure *11*). JSR's estimated annual economic value reached 446,390 Omani Rails (about 1.15 million $ [25]. It results from livestock, honey, frankincense, firewood, and charcoal activities [25]. The researcher and educators in 2022 were 89 [26]. From the questionnaire, there are challenges to monitoring illegal activities in most NRs, such as JSR and JQNR, because of terrain difficulty and existing equipment used in patrolling [17]. In JSR and TR, socioeconomic development plays the leading role in pressure that affect the reserves (Figure *12*). NRs managers should consider socio-economic development in NRs and around to avoid conflict with the community and stockholders [27].
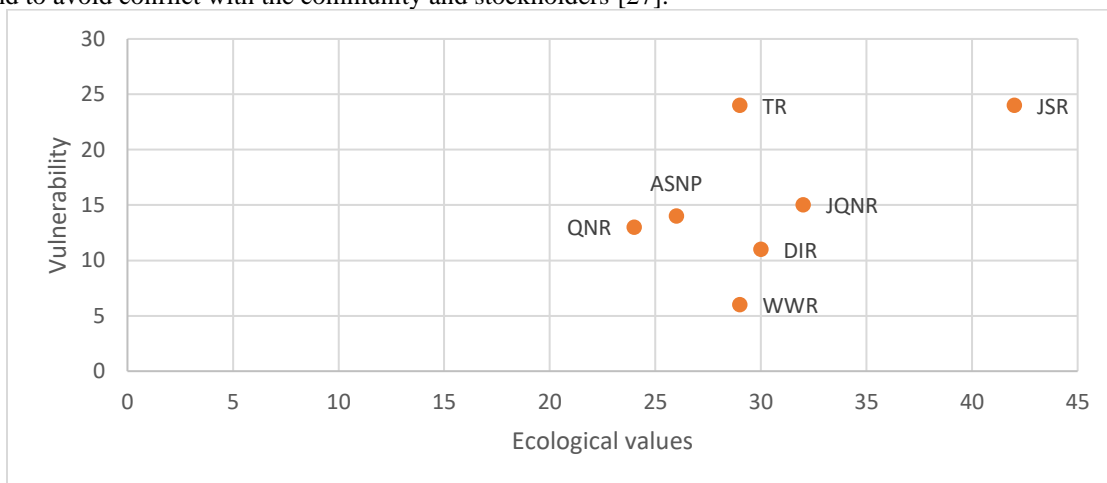
Figure 11: Correlation assessment between ecological values and vulnerability in NRs
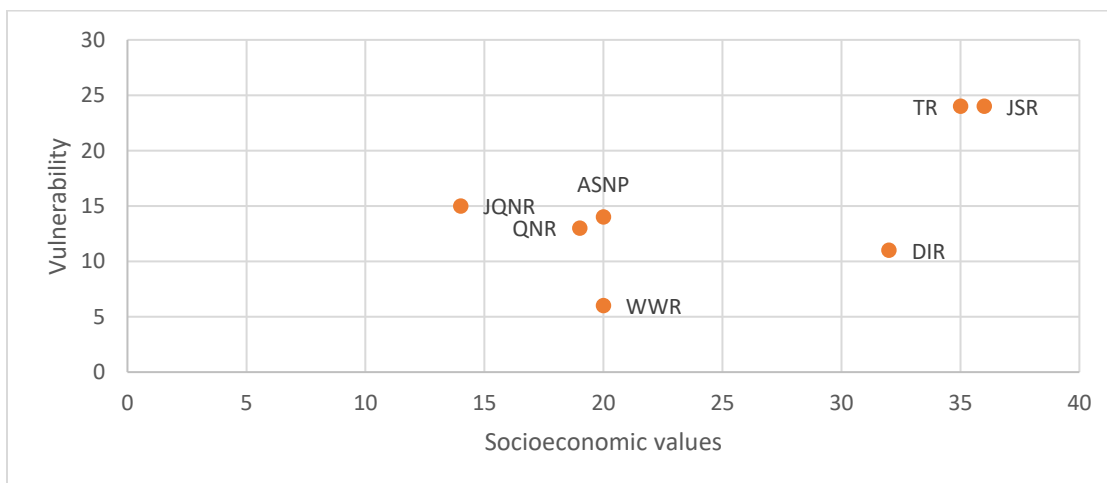
Figure 12: Correlation assessment between socioeconomic values and vulnerability in NRs

4.3. Management effectiveness

Generally, the effectiveness of management in NRs cases is at the basic level (0.42), (Figure *13*) which is lower than the global average (0.53) [22]. TR and WWR only received a high score (0.48) and (0.47) and JQNR got the lowest (0.33). Sultanate of Oman aims to protect 17% of biodiversity areas and 10% of the exclusive economic zone (EEZ) by 2024 [26]. More than setting goals to reach these targeted areas is needed because biodiversity globally is still under threat and decline [28]. That is why agencies and governments should preserve biodiversity through effective management [29].
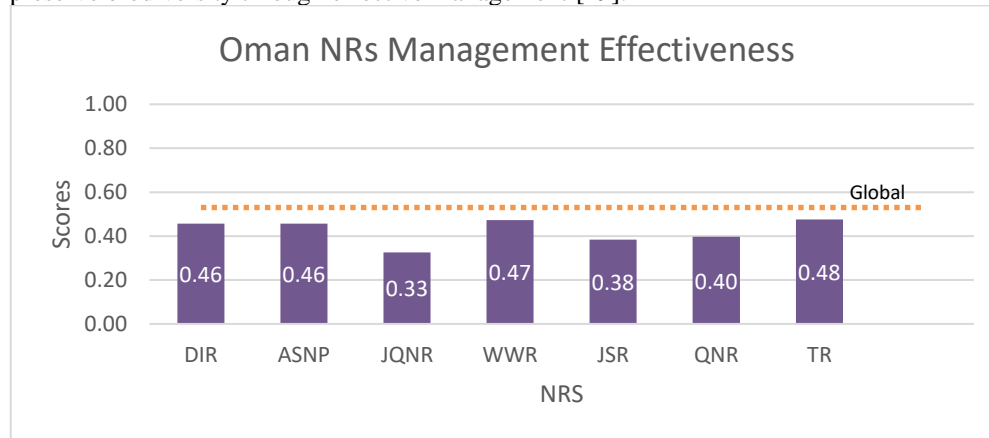
Figure 13: Management effectiveness of Oman NRs compared with the global average.

The following points figure out the key management issues of NRs in Oman;

- The current NRs management in the country mainly focused on law enforcement. Implementing law enforcement in NRs includes wildlife patrolling and collecting targeted data. This approach will be adequate and ineffective against the increase of pressures in and around the reserve.
- Financial management performance in NRs is low and directed by the main office in the governorate or Muscat. The financial administration is absent from most of the reserves, and there is no allocation budget for each..
- Some NRs haven't an administration section that could directly manage nature reserve activities and programs. This situation makes work more difficult and creates conflicts with other departments.
- NRs specialists and rangers lack continuous training and improvement programs focusing on nature reserve management and conservation topics..
- In the process, standards and procedures are not clarified and do not meet NRs management practices. Its main requirement to enhance Oman NRs management.
- Usually, management outputs depend on individual initiatives and are not a systematic procedure extracted from management plan goals.

Oman NRs planning phase total average is (0.51), which is in basic management requirement. The design of NRs is the lowest in scores due to unsustainable projects and development around the reserves. Also, most NRs management plans didn't include zoning plans that present the reserve's land use management and the suitable conservation practice for each area. In addition, the corridors and links between reserves or conservation areas are missed. There is no specific guideline, and which areas can be linked. From the site setting of NRs, ASNP existing boundary, designated before 1996 is not enough to conserve Arabian gazelle (*Gazella gazella*) habitat depending on available data [30-32]. This species categorized as Vulnerable on IUCN redlist [33, 34] Also, the critical corridor of Arabian leopard (*Panthera pardus nimr*) in Samhan mountain needs to be within JSR to ensure the critically endangered species is preserved [35]. However, corridors management should be legally represented at a high-level plan of the country which confirmed by other studies such as Tabarelli, M., et al [36].

In the objective theme, the existing operation in the reserves is not linked with the objectives in the management plan. Therefore, monitoring and tracking the achievement of management plan goals is difficult. Also, NRs staff face challenges in linking the operational management processes with the objectives set in the management plan. The administration should establish procedures so the local community can participate in reserves to support NRs goals and reduce conflicts with them [37].

The other important point in legislation is staff and financial support. This element is the lowest (0.28), and NRs suffer from illegal activities. The existing financial, human, and equipment resources are insufficient to meet law enforcement requirements. Law enforcement in NRs should be more effective by preparing conservation plans and identifying appropriate resources to implement.

The total average of NRs input score is (0.44). NRs infrastructure has the lowest score due to weak employee and visitor facilities. Some NRs do not include any staff facilities, such as JQNR and QNR. Another reserve is the facilities are not enough. One main issue in nature reserves is maintenance, which is unsuitable for long-term uses and procedures that take a long time. This issue should be

solved by allowing NRs to work with necessary maintenance requirements. Providing infrastructure in NRs for staff and visitors will contribute positively to protecting wildlife.

Human resources are an essential part of the input. The low score of this theme emphasizes the need for quantitative and qualitative human resources. Oman NRs existing human resources need building capacity in knowledge and skills of nature reserve management and conservation. Also, provide good work conditions, such as annual leave, work facilities, and prestige, and review staff performance based on reserve objectives.

All NRs do not include staff who can manage the reserve's financial aspects, including operation and allocation budget. The financial management (0.38) and allocation budget (0.24) is at a low level of management requirement. The allocation budget is below the global average (0.37) [22]. The low performance in NRs budget affects the operation and actions of conservation in the short and long term [38]. NRs management should assign an employee who is a finance specialist.

In information and communication, there are three weaknesses. First, the ecological and social data are not adequate for management requirements. The available data for nature reserve requires updates, and ranger's ecological and social data are not enough to understand the situation of NRs. Second, social data and information in NRs almost not exist because there is no social studies or surveys conducted. The available data and studies in some NRs need to be updated. Third, NRs do not include a database system that helps management to monitor, analyze and figure out important issues. All data are centralized and difficult to reach by NRs staff. Compared with [17] data collection equipment improved, including GPS, camera, camera traps, binoculars, and mobile phones. The data and information in NRs should be improved by establishing an effective database system. Also, there is a need for ongoing work on ecological and social studies in NRs [39]. In addition, local communities should be involved by EA in the issues that affect their livelihood and understand how NRs work and benefit them [37].

The process phase in the management cycle is the lowest (0.32). Usually, the absence of guidelines, standards, and procedures reflects on the process's performance [40]. The management plans in all NRs are old and require updates depending on (ecological and social) data and pressures analyses. Also, NRs managers should prepare an annual work plan that helps staff implement management plans because all operations in NRs do not meet management requirements.

The research, monitoring, and evaluation are low, affecting nature reserve management. The management plan should address these issues by establishing standards and procedures to meet the goals and objectives [39]. The collaboration and participation with related stakeholders and communities should be systematic. The absence of a clear administrative division in reserves and the dispersion of efforts will negatively affect the management. Each nature reserve should be an official administrative division. This step will facilitate nature reserve management.

NRs management outputs reflected the weakness in the inputs and processes during the last two years of the management cycle. The total average of the outputs was (0.43). All output elements are at the basic level of NRs management duties. Also, as previously mentioned that the absence of standards, procedures, and guidelines in activities and programs will affect processes and outputs at the same time. The outputs of planning and inventories, staff training and development, and site restoration are critical elements of NRs management outputs that have low performance. Focusing on patrolling approach in NRs explains the good score, but better mechanisms exist to manage NRs [39]. The correlation between input and output is present in (Figure 14) which is strong correlation (0.8). The increase in qualitative and quantitative inputs will positively influence in NRs output performance.

On the other hand, there were improvements in visitors management in ASNP are TR. compared with [17]. The other output elements, such as; wildlife management, community outreach, infrastructure, staff monitoring, and research output, should be enhanced by establishing ongoing programs for the long term.
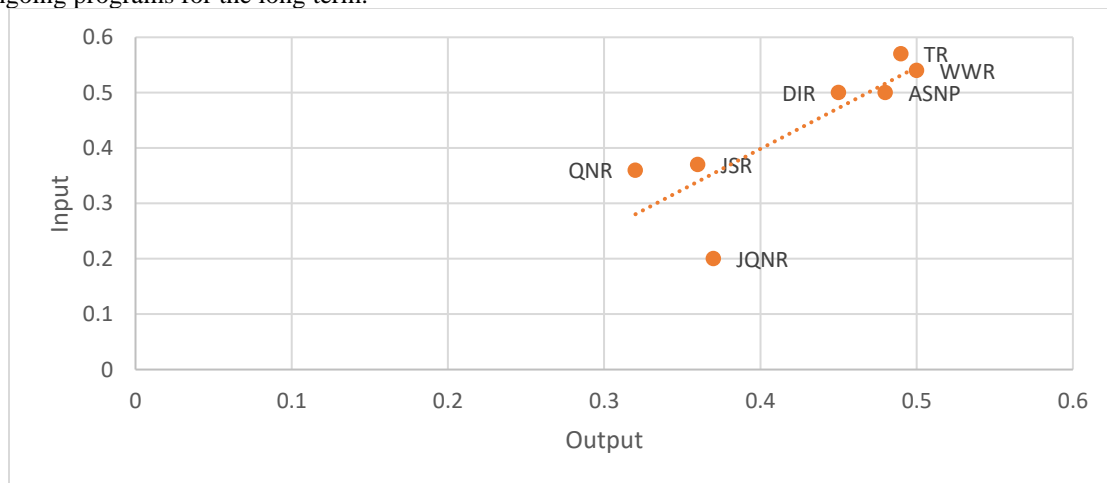

Figure 14: Correlation assessment between input and output in NRs

There was some limitation in the study faced by the researcher as mentioned below;

- The time planned was too short to finish seven workshops because the NRs are in different governorates with distances from 300 to 1000 km from each other. That situation needs to arrangement with NRs staff, transportation, set-up workshops, and site visits.
- Involving stakeholders was one of the challenges the study faced because of time limitations and availability in NRs cases. Also, some stakeholders had the ability to involve, and others did not.
- There were divergent of NRs rangers and specialist opinions in some cases, and it was difficult to voice their points in decision-making elements when their managers participated.
- The limitation of social data available. Also, in many NRs existing ecological data were more than five years old and needed updates. Those situations obliged researchers to find related data and studies from global databases and scientific journals.

5. Conclusion

Regarding NRs management effectiveness, the total average in NRs cases was (0.42). The score reflects the basic management duties of NRs. All nature reserves were under long-term security and proper biodiversity conservation goals in the planning phase. The significant challenges were setting objectives and linking with conservation assets, law enforcement resources, zonation, biodiversity corridors, and surrounding land uses. The total average of the planning phase was (0.51).

The score of the input phase was (0.44). The weaknesses in this stage were infrastructure facilities that focused on staff and visitors requirements, quantitative and qualitative human resources, and financial funding and management. Actually, the government has been the main budget funder for the last five years, and the following years reflect the stability of financial resources.

The process phase is direct and indirect, influenced by input resources. The total average process score was below management requirements (0.32). Many obstacles affected the process, such as; old management plans and the absence of annual work plans. Also, there were no clear procedures and standards for operational tasks. There were weaknesses in agencies and local communities involvement. The correlation between process and output was strong, affecting the output evaluation result. The NRs output depended on initiatives held by NRs staff. Threats prevention was the highest in outputs due to patrolling and law enforcement. There were improvements in vistors management in some NRs.

The methodology that the study used requires more effort to apply, for example, collecting data from all NRs, conducting workshops in NRs in different areas, and engaging stakeholders and local communities. These were the limitation of the research. The research is a baseline for further research, and EA could apply the methodology in other NRs. Also, the study figures out some issues, allowing future researchers to research it in depth. In addition, the study is the first step to help EA establish a national management effectiveness evaluation system. The study suggested solutions that could improve the performance of NRs in Oman, as below;

- Establish a framework that helps NRs managers to prepare management plans including conservation, research, monitoring, educational and ecotourism programs linked with targets.
- Develop legislative frameworks for NRs compatible with environmental issues and requirements of various activities.
- Build NRs national capabilities through continuous training and development programs. it could be "Rangers week" execute every year inviting experts around the country and world.
- Conduct periodic reports representing the achievement of goals and challenges. Also, using dashboards to present NRs performance.
- Introduce a financial sustainable approach and assign financial management specialists in NRs to deal with budgets, financial reports, concessions, expenditures, etc.
- Establish stockholders and communities engagement framework to ensure the efficiency of their participation.
- Prepare standards and operation procedures in NRs that help staff follow and improve the implementation of the management plans.
- Set appropriate NRs database depend on the nature of each nature reserve.

Authors

First Author Majid Alkhanbashi Master Candidate, Tongji University, UN Environment Tongji Institute of Environment for Sustainable Development (IESD): College of Environmental Science and Engineering; Email: alkhanbashi1@gmail.com, Phone No +968 96021287; Address: 1239 Siping Road, Shanghai 200092, China.
Second Author Fang Ping (Ph.D.) Mentor and Supervisor, Shanghai Institute of Pollution Control and Ecological Security; State Key Laboratory of Pollution Control and Resource Reuse; Key Laboratory of Yangtze River Water Environment, Ministry of Education, Tongji University, Email: fangping2000@tongji.edu.cn; Phone No +86 021 65983869; Address, Siping Rd 1239, Shanghai, 200092, PR China, 200092, PR China,

Appendix

Rapid Assessment and Prioritization of Protected Areas Management questionnaire (RAPPAM)

1. BACKGROUND INFORMATION

1 BACKGROUND INFORMATION

a) Name of protected area:
b) Date established:
c) Size of protected area:
d) Name of respondent:
e) Date survey completed:
f) Annual budget:
g) Specific management objectives:

h) Critical protected area (PA) activities:

2. PRESSURES AND THREATS

2 PRESSURES AND THREATS

Pressure:

○ Has ○ Has not been a pressure in the last 5 years

In the past 5 years this activity has: | The overall severity of this pressure over the past 5 years has been:

○ Increased sharply
○ Increased slightly
○ Remained constant
○ Decreased slightly
○ Decreased sharply

Extent
○ Throughout (>50%)
○ Widespread (15–50%)
○ Scattered (5–15%)
○ Localized (<5%)

Impact
○ Severe
○ High
○ Moderate
○ Mild

Permanence
○ Permanent (>100 years)
○ Long term (20–100 years)
○ Medium term (5–20 years)
○ Short term (<5 years)

Threat:

○ Will ○ Will not be a threat in the next 5 years

The probability of the threat occurring is: | The overall severity of this threat over the next 5 years is likely to be:

○ Very high
○ High
○ Medium
○ Low
○ Very low

Extent
○ Throughout (>50%)
○ Widespread (15–50%)
○ Scattered (5–15%)
○ Localized (<5%)

Impact
○ Severe
○ High
○ Moderate
○ Mild

Permanence
○ Permanent (>100 years)
○ Long term (20–100 years)
○ Medium term (5–20 years)
○ Short term (<5 years)

3. BIOLOGICAL IMPORTANCE – CONTEXT

3 BIOLOGICAL IMPORTANCE					Notes
y	m/y	m/n	n		
○	○	○	○	a) The PA contains a relatively high number of rare, threatened, or endangered species.	
○	○	○	○	b) The PA has relatively high levels of biodiversity.	
○	○	○	○	c) The PA has a relatively high degree of endemism.	
○	○	○	○	d) The PA provides a critical landscape function.	
○	○	○	○	e) The PA contains the full range of plant and animal diversity.	
○	○	○	○	f) The PA significantly contributes to the representativeness of the PA system.	
○	○	○	○	g) The PA sustains minimum viable populations of key species.	
○	○	○	○	h) The structural diversity of the PA is consistent with historic norms.	
○	○	○	○	i) The PA includes ecosystems whose historic range has been greatly diminished.	
○	○	○	○	j) The PA maintains the full range of natural processes and disturbance regimes.	

4. SOCIO-ECONOMIC IMPORTANCE – CONTEXT

4 SOCIO-ECONOMIC IMPORTANCE					Notes
y	m/y	m/n	n		
○	○	○	○	a) The PA is an important source of employment for local communities.	
○	○	○	○	b) Local communities depend upon the PA resources for their subsistence.	
○	○	○	○	c) The PA provides community development opportunities through sustainable resource use.	
○	○	○	○	d) The PA has religious or spiritual significance.	
○	○	○	○	e) The PA has unusual features of aesthetic importance.	
○	○	○	○	f) The PA contains plant species of high social, cultural, or economic importance.	
○	○	○	○	g) The PA contains animal species of high social, cultural, or economic importance.	
○	○	○	○	h) The PA has a high recreational value.	
○	○	○	○	i) The PA contributes significant ecosystem services and benefits to communities.	
○	○	○	○	j) The PA has a high educational and/or scientific value.	

y – yes m/y – mostly yes m/n – mostly no n – no

5. VULNERABILITY – CONTEXT

5 VULNERABILITY					Notes
y	m/y	m/n	n		
○	○	○	○	a) Illegal activities within the PA are difficult to monitor.	
○	○	○	○	b) Law enforcement is low in the region.	
○	○	○	○	c) Bribery and corruption is common throughout the region.	
○	○	○	○	d) The area is experiencing civil unrest and/or political instability.	
○	○	○	○	e) Cultural practices, beliefs, and traditional uses conflict with the PA objectives.	
○	○	○	○	f) The market value of the PA resources is high.	
○	○	○	○	g) The area is easily accessible for illegal activities.	
○	○	○	○	h) There is a strong demand for vulnerable PA resources.	
○	○	○	○	i) The PA manager is under pressure to unduly exploit the PA resources.	
○	○	○	○	j) Recruitment and retention of employees is difficult.	

6. OBJECTIVES – PLANNING

6 OBJECTIVES					Notes
y	m/y	m/n	n		
○	○	○	○	a) PA objectives provide for the protection and maintenance of biodiversity.	
○	○	○	○	b) Specific biodiversity-related objectives are clearly stated in the management plan.	
○	○	○	○	c) Management policies and plans are consistent with the PA objectives.	
○	○	○	○	d) PA employees and administrators understand the PA objectives and policies.	
○	○	○	○	e) Local communities support the overall objectives of the PA.	

7. LEGAL SECURITY – PLANNING

7 LEGAL SECURITY					Notes
y	m/y	m/n	n		
○	○	○	○	a) The PA has long-term legally binding protection.	
○	○	○	○	b) There are no unsettled disputes regarding land tenure or use rights.	
○	○	○	○	c) Boundary demarcation is adequate to meet the PA objectives.	
○	○	○	○	d) Staff and financial resources are adequate to conduct critical law enforcement activities.	
○	○	○	○	e) Conflicts with the local community are resolved fairly and effectively.	

8. SITE DESIGN AND PLANNING – PLANNING

8 SITE DESIGN AND PLANNING	Notes
y m/y m/n n	
○ ○ ○ ○ a) The siting of the PA is consistent with the PA objectives.	
○ ○ ○ ○ b) The layout and configuration of the PA optimizes the conservation of biodiversity.	
○ ○ ○ ○ c) The PA zoning system is adequate to achieve the PA objectives.	
○ ○ ○ ○ d) The land use in the surrounding area enables effective PA management.	
○ ○ ○ ○ e) The PA is linked to another area of conserved or protected land.	

9. STAFFING – INPUTS

9 STAFFING	Notes
y m/y m/n n	
○ ○ ○ ○ a) The level of staffing is sufficient to effectively manage the area.	
○ ○ ○ ○ b) Staff members have adequate skills to conduct critical management activities.	
○ ○ ○ ○ c) Training and development opportunities are appropriate to the needs of the staff.	
○ ○ ○ ○ d) Staff performance and progress on targets are periodically reviewed.	
○ ○ ○ ○ e) Staff employment conditions are sufficient to retain high-quality staff.	

10. COMMUNICATION AND INFORMATION – INPUTS

10 COMMUNICATION AND INFORMATION	Notes
y m/y m/n n	
○ ○ ○ ○ a) There are adequate means of communication between field and office staff.	
○ ○ ○ ○ b) Existing ecological and socio-economic data are adequate for management planning.	
○ ○ ○ ○ c) There are adequate means of collecting new data.	
○ ○ ○ ○ d) There are adequate systems for processing and analysing data.	
○ ○ ○ ○ e) There is effective communication with local communities.	

11. INFRASTRUCTURE – INPUTS

11 INFRASTRUCTURE	Notes
y m/y m/n n	
○ ○ ○ ○ a) Transportation infrastructure is adequate to perform critical management activities.	
○ ○ ○ ○ b) Field equipment is adequate to perform critical management activities.	
○ ○ ○ ○ c) Staff facilities are adequate to perform critical management activities.	
○ ○ ○ ○ d) Maintenance and care of equipment is adequate to ensure long-term use.	
○ ○ ○ ○ e) Visitor facilities are appropriate to the level of visitor use.	

12. FINANCES – INPUTS

12 FINANCES   Notes

	y	m/y	m/n	n	
a)	○	○	○	○	Funding in the past 5 years has been adequate to conduct critical management activities.
b)	○	○	○	○	Funding for the next 5 years is adequate to conduct critical management activities.
c)	○	○	○	○	Financial management practices enable efficient and effective PA management.
d)	○	○	○	○	The allocation of expenditures is appropriate to PA priorities and objectives.
e)	○	○	○	○	The long-term financial outlook for the PA is stable.

13. MANAGEMENT PLANNING – PROCESSES

13 MANAGEMENT PLANNING   Notes

	y	m/y	m/n	n	
a)	○	○	○	○	There is a comprehensive, relatively recent written management plan.
b)	○	○	○	○	There is a comprehensive inventory of natural and cultural resources.
c)	○	○	○	○	There is an analysis of, and strategy for addressing, PA threats and pressures.
d)	○	○	○	○	A detailed work plan identifies specific targets for achieving management objectives.
e)	○	○	○	○	The results of research and monitoring are routinely incorporated into planning.

14. MANAGEMENT DECISION MAKING – PROCESSES

14 MANAGEMENT DECISION MAKING   Notes

	y	m/y	m/n	n	
a)	○	○	○	○	There is clear internal organization.
b)	○	○	○	○	Management decision making is transparent.
c)	○	○	○	○	PA staff regularly collaborate with partners, local communities, and other organizations.
d)	○	○	○	○	Local communities participate in decisions that affect them.
e)	○	○	○	○	There is effective communication between all levels of PA staff and administration.

15. RESEARCH, MONITORING, AND EVALUATION – PROCESSES

15 RESEARCH, EVALUATION, AND MONITORING   Notes

	y	m/y	m/n	n	
a)	○	○	○	○	The impact of legal and illegal uses of the PA are accurately monitored and recorded.
b)	○	○	○	○	Research on key ecological issues is consistent with the needs of the PA.
c)	○	○	○	○	Research on key social issues is consistent with the needs of the PA.
d)	○	○	○	○	PA staff members have regular access to recent scientific research and advice.
e)	○	○	○	○	Critical research and monitoring needs are identified and prioritized.

16. OUTPUTS

16 OUTPUTS				In the last 2 years, the following outputs have been consistent with the threats and pressures, PA objectives, and annual workplan:	Notes
y	m/y	m/n	n		
○	○	○	○	a) Threat prevention, detection and law enforcement.	
○	○	○	○	b) Site restoration and mitigation efforts.	
○	○	○	○	c) Wildlife or habitat management.	
○	○	○	○	d) Community outreach and education efforts.	
○	○	○	○	e) Visitor and tourist management.	
○	○	○	○	f) Infrastructure development.	
○	○	○	○	g) Management planning and inventorying.	
○	○	○	○	h) Staff monitoring, supervision, and evaluation.	
○	○	○	○	i) Staff training and development.	
○	○	○	○	j) Research and monitoring outputs.	

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