Why wild herbivores raid crops: alternative hypotheses and their differential implications for mitigation of human wildlife conflict

Running title: Alternative causal hypotheses for crop raiding

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Abstract: Wild herbivores devouring crops is a major issue in human wildlife conflict. Although there is substantial literature that identifies the conflict, tries to estimate the extent of economic loss, its consequences and also suggests some mitigation measures, many fundamental issues remain unaddressed. A number of speculations about the root causes behind the problem have been made but they haven't been treated and tested as alternative hypotheses. In four sections of this article (A) we make a list of alternative hypotheses, collected from a wide variety of sources, (B) evaluate their plausibility, logical integrity and compatibility with existing data (C) suggest differential testable predictions and (D) discuss their differential implications for mitigation measures. It is important to identify the locale specific causes of the conflict because the efficacy of mitigation measures would crucially depend upon the predominant underlying cause. Measures applied without a good understanding of the causal factors might turn out to be ineffective and even counterproductive. Substantial research needs to be focused on differentially testing the predictions of the alternative hypotheses in order to be able to handle the problem and promote healthy coexistence of wildlife with indigenous people. Although our perception of the problem and illustrative examples are in the Indian wildlife context, some of the emerging outcomes will have global importance.

Introduction:

Free ranging wild species of herbivores often visit agricultural lands and eat, trample, uproot or otherwise damage crops. The severity of this problem is highly variable across landscapes but the problem appears to be widespread globally (Graham et al 2010, Mackenzie and Ahabyona 2012, Karanth et al 2013, Bayani et al 2016, IUCN 2022, Yazezew 2022). A number of mitigation measures have been suggested, often debated and variously implemented with different degrees of success (Sitati and Walpole 2005, King et al 2009, Massei et al 2010, Hoare 2012,2015, Krivek et al 2020, Karanth and Wanamamalai 2020). Compensating the affected farmers has been shown to help maintain a positive attitude towards conservation (Karanth et al 2018, Johnson et al 2018, Joshi et al 2020) but with increasing frequency and extent of damage, this is unlikely to provide a sufficient and long lasting solution. It is necessary to examine the root causes of the problem. The question why wild herbivores raid crops and the factors that influence the frequency and severity of damage has not been adequately addressed so far. There is a need to examine the different causal hypotheses because they have different and often mutually contradicting implications for mitigation measures. The failure of some of the mitigation measures and the tricky implementation (Hoare 2012, 2015) may be because they were based on a wrong causal assumption.

We state alternative hypotheses, examine them against existing knowledge, data and anecdotes, state testable predictions and discuss their possible implications for effective management in this paper. The hypotheses are not mutually exclusive. More than one factor might be simultaneously acting in a locale specific manner. But it is important to identify the relative importance of them, in order to design mitigation strategies accordingly.

Since studies addressing causal analysis are scanty, we cannot test those hypotheses with existing data right away. We therefore take an approach of making multiple testable predictions from each of the hypotheses. Testing the predictions is a demanding task and we expect that the article would initiate attempts in this direction. Identifying the right causes and applying appropriate solutions specifically addressing the causes is important. Often misleading perspectives and mitigations measures based on them have resulted into profound injustice to indigenous people which can be avoided with a well researched approached.

A. Collection of hypotheses

Since there is limited scientific literature on examining hypotheses for crop raiding collectively, we did not intend a systematic review. , We listed plausible hypotheses from a variety of sources including research articles, popular articles by wildlife researchers, the opinions of indigenous communities, our own anecdotes, observations and thinking.

There is a simplistic baseline set of assumptions behind the set of hypotheses being stated. Individual assumptions from this set are challenged in the context of specific hypotheses. But apart from that the common assumptions need not be stated every time with each hypothesis. We assume, to begin with that wildlife has a specific preferred habitat different from human habitation, animals prefer to use this habitat by default, prefer natural forage over feeding opportunities made available by humans and have an intrinsic tendency to avoid ancounters with humans as far as possible. If the baseline set of assumptions is true, majority of conflict will be along the length of the boundary as found empirically as well (Bayani et al 2016, Mamo et al 2021). This set of assumptions is obviously oversimplified but forms a baseline to begin. Specific assumptions can be relaxed or challenged contextually.

Hypothesis 1: Although we did not find any studies establishing causal relationship between habitat loss and crop raiding severity, this is the cause most commonly believed and stated by naturalists and wildlife researchers in academic as well as popular writings (Agarwal et al 2016, Hareohay et al 2017, Mekonen 2020, Gross et al 2021, Yazezew 2022, IUCN 2022, 2023, Negi et al 2023, IFAW 2024). A plausible logic appears to be that animals prefer to remain in their preferred natural habitat but when these are destroyed, fragmented or disturbed they are forced to move out. When they move out they raid crops as an alternative and presumably suboptimal source of food. There are at least five different streams of thinking within this broader hypothesis.

a. Net habitat depletion such as by deforestation: The most common perception is that of habitat loss due to deforestation. By this hypothesis wild animals are deprived of the prime habitat they prefer to inhabit. Only because of unavailability of the preferred habitat they are compelled to move out. This hypothesis is mainly propagated by the wild life enthusiasts and appears to be uncritically accepted by

most wildlife researchers as well. Although there are no serious research publications supporting this hypothesis, it is often reiterated rhetorically in popular literature propagated by wild life researchers and organizations (for example IUCN 2022, WWF 2024, IFAW 2024). Before being propagated as the cause of human wildlife conflict, it needs to be tested in comparison with alternative hypotheses.
Habitat loss can be contiguous or in fragments. The two types have different consequences on the interactive border. Fragmentation typically leads to much greater interactive boundaries.

b. Hurdles in movement, connectivity between habitat patches in heterogeneous landscapes: Local migration over variable distances is a normal pattern of behaviour of many species, particularly large herbivores. When the landscape is heterogeneous and mixed with human habitation, animals need to move through agricultural areas and may lead to crop destruction to a variable extent. Although the interaction between connectivity and conflict is extensively discussed (Goswami and Vasudev 2017, Vasudev et al 2023), the causality in the complex interplay is not yet investigated.
c. Habitat loss due to conservation norms: In our own experience, this possibility was expressed by many individuals from the local communities affected by the conflict. It is thought that because of the policy of complete ban on tree felling, extraction and collection from protected areas open patches, grasslands and secondary forests are getting increasingly replaced by tall tree canopy forests. Secondary forests and forest grassland mosaics offer greater feeding opportunities to herbivores (Joshi et al 2018). Local communities think that since the complete ban on forestry operations, canopy forests are taking over the open patches making the habitat less favorable for herbivores.
d. Invasive species: In some areas invasive species are rapidly replacing local palatable species leading to change in land use by herbivores (Rozen-Rechels 2017) that may lead to raiding crops (Krivek et al 2020).
e. Pinch periods: Water availability in certain seasons is perceived to be a main cause why animals move to the vicinity of human settlement, where water is more likely to

be available throughout the year. Once they move close to human habitation for water, they inevitably feed on and damage locally available sources.
Apart from water seasonal pinch for many other resources is possible. Forests in India are highly seasonal and there are periods in the seasonal cycle where forage in the wild is largely depleted. If crops are standing during this pinch period, animals are attracted to it as the only source of food during the pinch period.

Hypothesis 2: Population growth: As profound success of the conservation strategies the populations of many wild species have increased substantially during recent decades. Expanding the range and dispersing are natural instinctive responses to overcrowding. So the phenomenon of animals moving out from protected areas is an inevitable effect of increasing populations (Matthysen 2005).

Hypothesis 3: Greater nutritive value of crops: The advent of agriculture in human history changed human ecology substantially. The plants selected as crop species were particularly rich in nutritive value and poor in secondary metabolites. Over several generations there has been selective breeding for better nutritional quality and reduced secondary metabolites. Therefore crops, in general, have greater palatability than wild forage (Hill 2018, Plotnik et al 2023). Therefore, wherever herbivores have a choice of wild forage versus crops, other things being equal, they will prefer crops over wild forage (Delger *et al*., 2011, Chiyo et al 2011). By this hypothesis, in contrast with hypothesis 1, animals are pulled by better nourishment prospects and not pushed out by dearth of fodder in the wilderness.

Hypothesis 4: Disappearing human fear: According to this hypothesis, animals have a fear of humans since humans have been a hunting species from an early ancestral stage. The hunting practice became more efficient and thereby destructive with development of technology. Therefore by natural selection, learning and cultural inheritance a tendency to avoid humans developed in the wild animals. If animals prefer wilderness to human settlements as assumed by hypothesis 1, it is because of the fear of humans than because of preferred food and other aspects of the habitat. Since the implementation of complete ban on hunting in India from the 1970s, this process is reversing rapidly. With progressive loss of human avoidance behaviour, use of landscapes with human habitation is increasing.

An interesting possibility is generated by poaching. Since implementation of the ban on hunting, poaching has dwindled but still prevalent in remote parts where law and order is weak. Since poachers and presumably natural predators prefer areas away from human settlements, herbivores may learn to perceive the vicinity of settlements to be a safer habitat then remote forests (Price et al 2014). Wherever the poaching pressure is sufficiently intense, it is possible that animals prefer human habitation over forests, particularly at night. Thus area specific success or failure of the ban on hunting is expected to affect human animal conflict in unintended ways.

One more possible outcome of the progressive loss of fear is observed when people try to drive away animals by shouting and the use of drums, fire crackers and other means. This is intended to frighten them away. However, when the fear of man reduces below a threshold, this would result into irritability more than fear. The irritability may result into increased attacks and casualties. The devices meant for scaring away that work effectively at a higher level of intrinsic fear, may turn counterproductive below a threshold level. This possibility needs to be considered seriously since people appear to use it extremely commonly.

B. Logical integrity, limitations and possible flaws in the hypotheses in the light of existing data, knowledge and anecdotes:

The assumption of the habitat loss family of hypotheses that animals prefer to stay in their natural habitats and avoid human dominated landscapes raises multiple questions. The distinction of land as natural habitats versus human settlements is not very old in the evolutionary and ecological history. In some areas human settlement is very recent. The demarcation of protected areas is quite artificial. The assumption that animals intuitively prefer natural habitats is therefore questionable (Shrivastava et al 2020). They have coevolved and coexisted with human species sharing the habitats. Agricultural lands are difficult to distinguish from grasslands which are their natural habitats. So the assumption that animals avoid human occupied landscapes unless their presumed natural habitat is lost or fragmented remains unsubstantiated.

The loss of habitat hypothesis also suffers from the short term versus long term effects and logical inconsistencies associated with it. In the short run, if the animal population is assumed constant and if their habitat shrinks, they will be forced to move out of the presumed preferred habitats. However, if the habitat is crucial for their breeding, loss of habitat will also reduce the breeding rate and the population will dwindle. Therefore in the long run, habitat loss is unlikely to cause sustained conflict. In contrast, if we assume that they can breed even after loss of habitat, then the assumption that the habitat is crucial for their survival is under question.

The assumption that many species of primates and small herbivores inhabit and breed in their "natural habitats" (i.e. mostly protected areas in recent times) and only come out to raid crops in certain seasons and certain times gets challenged by the recent observations that they often stay and breed within agricultural or horticultural areas. They often do not need natural forests. In some parts of India many generations of wild boar, langurs, macaques and antelopes have not seen "natural" habitats and they successfully breed within the cultivated habitats. However since almost all large mammalian wild life research is restricted to protected areas, there is little data on populations outside the presumed natural habitats. It is possible that preference to the presumed natural habitat was induced by the fear of man, largely owing to hunting. After hunting has been officially banned, this distinction is expected to vanish in subsequent generations. Therefore there is no need to consider animal movements outside their presumed natural habitats as anything unnatural. The habitat loss family of hypotheses thus suffers from an inherent logical contradiction. Nevertheless they need to be examined seriously using their testable predictions.

The natural attraction of crops owing to their greater nutritive value is quite likely since crop raiding elephants are observed to be larger and fattier (Chiyo et al 2011). It is possible that elephants move through crop lands not only because they fall in their migration routes, but they choose these paths over alternative paths because of their nutritive advantage. Higher nutritive value of crops, increasing preference to crops because of gradual loss of human fear are less popular hypotheses among wildlife researchers, but they will have to be considered and examined since they suggest a different approach for mitigating conflicts.

C. Differential testable predictions

The set of possible hypotheses are not mutually exclusive. However, assessing their relative role is important for designing appropriate mitigation strategies. Also the relative importance of different causal factors can vary contextually and therefore the predictions also need to be tested in locale specific manner. For testing the differential predictions it is crucial to have access to reliable data. Testing the suggested predictions with dubious data sources is likely to be misleading. Currently although qualitatively the problem is known to exist, there are no reliable quantitative measures of the extent of loss in different areas. Therefore although on ground testing may not be possible as of today, we state the testable predictions with the hope that sufficient research inputs will be made in near future to collect reliable and comparable data.

Correlation between forest cover and habitat quality is expected according to the sub-hypotheses *a* of the habitat degradation group. If deforestation, habitat fragmentation, invasive species or net loss of preferred habitats is the major cause of conflict, we expect a negative correlation between forest cover and crop damage across area units such as district, taluks, beats or circles. The correlation needs to be robust to corrections for area cultivated, the extent of forest agriculture interface and other confounding factors. Across the state of Maharashtra, districts with greater forest cover have lower agricultural productivity per unit land under cultivation and further a negative time trends (manuscript under preparation). Many other factors converge to imply wild herbivore depredation as a major causal factor for this trend. This trend contradicts the habitat loss hypotheses, but the generality of this trend needs to be examined carefully.

Although the complexity of the interaction between connectivity and conflict is well documented (Goswami 2017, Vasudev et al 2023), the causality is not clear. Whether migration routes are independent and crop loss is an inevitable effect of cropland being present along the route, or whether the nutrition obtained from crops is a significant factor in deciding the spatio-temporal patterns of migration is an important question. If nutritional benefits from crop raiding are primary, one would observe animals moving from a forest patch to crop land and returning to it quite often. In contrast this pattern of movement will not be observed if migration is causal to crop raiding. Crop raiding would be seen only during migration.

If the loss of open patches and secondary forests are critical, a finer level classification using appropriate tools should reveal a positive correlation of crop damage with increase in canopy forest or negative correlation with non-agricultural open patches within the habitats. If invasive species are mainly responsible for the habitat loss, the rise in area covered by the invasive species should be correlated with the rise in crop damage and this correlation should remain after correcting for confounding factors. Also weeding out should demonstrably reduce the frequency and extent of damage (Krivek et al 2020). If water constraints drive animals close to human habitats, provision of water resources within PAs will reduce crop damage quickly. This is being done in most wildlife parks today. However, no systematic data appears to be maintained to test whether better water availability throughout the year in PAs reduces the conflict.

In certain areas habitats have been evidently restored that can help in testing certain predictions. For example in certain patches along the wastern ghats and costal Maharashtra there was large scale deforestation by the middle of the 20th century because of charcoal making (Sathe 1988). After charcoal was substituted by kerosene and then by LPG gas as domenstic fuel, charcoal making ceased in most areas and secondary forests grew back substantially. In these areas the problem of crop damage should have reduced after the habitat restoration. It is difficult to get data about the amount of crop damage in the past for any quantitative analysis. The perception of old people is on the contrary. The perceived crop damages have increased after the habitat restoration. Since retrospective analysis is difficult due to lack of crop damage data, prospective studies need to be undertaken. Wherever ecological restoration is attempted over sufficiently large area crop damage should decrease significantly. Management of many protected areas includes regeneration, grassland management, provision of water and weeding off invasive species. These protected areas offer us opportunities to test many of the predictions. By the habitat loss family of hypotheses, crop damage in and around such areas should decrease with good management. Although records of good management and habitat restoration data are available for many protected areas in India, reliable temporal trends in crop loss are not available for testing these predictions as of today.

If increase in population is a necessary and sufficient cause, correlations across area units between population estimates and crop damage should be observed after correcting for confounding variables. While a positive correlation is most likely, the critical question is how much variance in crop damage is explained by population density.

Whether animals prefer wild forage or crop species is relatively easy to test by two lines of investigation. A very promising testable prediction can come through nutritional analysis of wild forage compared with locally grown common crops at appropriate stages of development. A prior requirement of such a study is that the feeding habits of the herbivore species need to be known. Alternatively using captive animals, choice experiments can be performed between common wild forage and locally grown crops at the appropriate stage of development. This is very likely to clearly differentiate between whether animals prefer natural forage and come out only when it is inadequate, or whether they prefer crop species, other things being equal. If they appear to prefer crop species under otherwise identical conditions, the question changes to what prevents them from eating only crops almost all the time. This is very likely to be fear and avoidance of humans. If that is true, it follows that loss of this fear will increase the conflict.

Another testable prediction of this line of thinking is that wherever traditional hunting practices by communities are still prevalent, crop damage should be less serious because the fear of humans is reinforced. This is testable if reliable data on traditional hunting/poaching is available, which is the tricky part of the prediction testing. The corollary is easier to test. It is possible to quantify human avoidance behaviour. The ease of sighting wild animals, absence of any response to tourists or flight distance in response to approach on foot across protected areas should be correlated with crop damage in surrounding villages and this correlation should stand after correcting for population density. Another observable pattern is that when human avoidance behaviour is strong, the crop damage problem wouls be intense only at the interactive border between natural habitat and agricultural land. But as human avoidance becomes weak, damage away from the border would increase in proportion.

At a finer seasonal scale, one can distinguish between a push hypothesis which states that animals tend to move out during the pinch periods of food availability within the forest; versus the pull hypothesis which states that animals are attracted by the more nutritious crops. A careful look at the phenology of food availability within forests and maximum nutritive stages of crop vis a vis animal movements and season specific extent of crop damage can resolve between the push and pull hypotheses. Crop raiding should be restricted to seasons when food availability within the forests is low independent of crop availability if the push hypothesis is correct. On the other hand, crop raiding incidents should increase when the crops are at their peak nutritious stage, independent of wild forage availability. This distinction is easier to test and interpret as well as has important implications for mitigation.

If reliable data on farm specific crop damage are available more hypotheses-resolving predictions can be made. Ideally a sound mathematical modeling approach is needed to make more precise qualitative and quantitative predictions. Developing such a model is out of scope of this article but can be an effective tool to make and test differential predictions. Some apparently counterintuitive and deceptive predictions need a mathematical approach. For example if the interaction boundary length increases because of fragmentation or agricultural encroachment, then the net damage may increase but the average damage per unit farm area is expected to decrease because animals would get divided over greater agricultural area. This prediction contradicts the common perception that encroachment increases crop damage (Agarwal et al 2016, Hareohay et al 2017, Mekonen 2020, Gross et al 2021, Yazezew 2022, Negi et al 2023), such issues need a rigorous mathematical approach.

Table 1 summarizes the different hypotheses and sub-hypotheses, the testable predictions and the model-prediction matrix. The matrix is a good means to resolve between hypotheses employing a battery of testable predictions. If the relative importance of the causal factors is clear, appropriate mitigation measures can be employed as under.

D. Implications for mitigating conflict

If habitat loss is the cause, mitigation is inherently difficult. Habitat loss needs to be prevented and restoration attempted in any case, independent of its relation with crop damage. The importance of habitat protection and restoration is not under question, but whether habitat restoration will be effective in preventing crop damage is the question. The expected time required for restoration is large; in the meanwhile the populations may adapt to presumed suboptimal habitats and keep breeding outside the so called preferred habitat. With increase in populations the restored habitat is likely to turn inadequate. Therefore although restoration needs to be done for multiple other reasons, we cannot expect it to resolve the crop damage problem.

If croplands obstructing connectivity routes is the main cause of crop damage, protecting farmlands with energized or non-energized fences while keeping a sufficient passage along the pre-identified migratory route should work. If the path is unobstructed, animals need not enter croplands. Conversely if nutrition is a major causal factor in determining migration routes, they will try to enter croplands even when shortest unobstructed paths are available. Potentially relocating villages and croplands along the pre-identified migration paths would work if migration is causal to crop damage. However, if nutrition has a causal role, after relocation animals might change the route to cover other croplands.

If the open patch and secondary forest hypothesis is correct, the classical Indian policy of wildlife management consisting of ban on all human activities needs to give way to a well managed resource use. Periodic and carefully calculated extraction of timber and other forest produce might be desirable. There are multiple unknown variables important for this type of management and that needs huge research inputs in a new direction.

If increasing population is the necessary and sufficient cause, population control is the only possible solution. This can be achieved by carefully calculated and controlled culling or permitted hunting; or alternatively by castration/contraception. Culling is safest from ecological point of view whereas male castration has greater risk of local extinction, large population fluctuations and loss of genetic diversity (Watve and Dandekar, MS under preparation). These risks are much smaller in calculated culling.

If the nutritive value and thereby attractiveness of crops is proved to be greater than wild forage at least in some seasons, then crop raiding needs to be assumed as inevitable. If the hypothesis that the fear of humans has been the factor minimizing crop raiding in spite of its attractiveness is correct, then attempts to restore the fear of humans is the most promising solution. Here hunting can be used only as a tool. The objective of hunting by this and the previous hypothesis is different. Research inputs to design appropriate hunting/culling practices that would reinstate necessary level of human avoidance behaviour will be able to mitigate the problem substantially with minimum required killings. If culling is systematically designed to facilitate human avoidance behaviour, then the effect would be disproportionately greater than the proportion actually killed. Here more than the calculation of how many need to be culled, the method of hunting/culling needs to be selected appropriately to effectively change behaviour of the species.

On the other hand, if killing or castration only reduces the population but the attractiveness of crops and disappearing fear of humans persists, then the effect will be less than the proportion culled. It is likely that dominant and larger individuals/groups take to crop raiding owing to its greater nourishing content. Weaker individuals/groups keep away from the stronger groups. But if the crop raiding animals are removed the subordinate ones take their place very soon (Plotnik et al 2023). If this is true, reduction in conflict by culling or removing animals would be disproportionately ineffective. Such factors might be responsible for the observed ineffective culling (Hoare 2012, Cappa et al 2021). The subtleties of animal behaviour are important in designing mitigation measures but studies considering behavioural factors related to farmer herbivore conflict are still largely inadequate (Watve et al 2016, Bayani and Watve 2016, Plotnik et al 2023).

Shifting the crop choice has been shown to be effective on a small scale (Gross et al 2016) but this strategy has two potential problems. One is that animals also known to change their feeding habits and what is considered inedible today may not be so all the time. The second more important consideration is the economics of the alternative crop. Crop choice is decided by direct use to the farmers and the market value. The suggested alternative crops may not be of direct use to the farmers and if a large numberof farmers shift to another crop itsmarket value can collaps rapidly. Therefore this alternative needs careful considerations of its economics.

Independent of the cause of conflict and the appropriateness of alternative mitigation measures, it is necessary to have an appropriate and realistic compensation strategy giving relief to affected farmers. If realistically assessed, the reduction in compensation needed can also serve as an appropriate marker of the success of the measures. Such data can be collected with minimum efforts and maximum reliability if appropriate compensation protocols are applied (Joshi et al 2021). Monitoring changes in populations, their spatial distribution and behaviour demands much greater and continued research inputs. Therefore a minimum hassle and realistic damage compensation protocol is extremely critical under any circumstances. Innovative protocols based on the principles of game theory are demonstrated to work very well on pilot scale (Joshi et al 2021).

Substantial research inputs are nevertheless needed on the multiple other dimensions of the problem in order to make the mitigation measures effective with minimum damage to the populations. So far wildlife research and management in India has largely focused on giving protection and allowing populations to grow. This was a relatively easy challenge. The challenge of the future to monitor populations outside PAs, keeping the conflict to a minimum and ensuring population viability of the species is orders of magnitude difficult challenge and would require research inputs proportionately. This needs a paradigm change in wildlife research and scientists in this field need to be prepared for a major change in their mindset.

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Table 1:

A summary of the hypotheses, their testable predictions and implications for mitigation.

a. The hypotheses and their differential implications for mitigation measures. The hypotheses numbers are used for ease of tabulation below.
b. A list of testable predictions that can resolve between alternative causal hypotheses. The prediction numbers are used below for simplicity in table 1c.
c. A hypotheses-prediction matrix that can be used to determine causality.

a.

		Hypothesis	**Mitigation and Management**
1.		**Animals are forced to move out when their natural habitat are destroyed, fragmented or disturbed.**	
	A	Destruction of the preferred habitat	Collective efforts in restoration of degraded habitats
	B	Fragmentation that affects movement and habitat connectivity.	Corridors for connectivity. Protecting farmlands near the migration paths with energized or non-energized fences.
	C	Over-restoration such as canopy forests taking over the open patches	Well informed active habitat management rather a total ban on cutting/resource use
	D	Invasive species rapidly replacing local palatable species	Weeding out invasive species
	E	Water availability in human settlement during dry season attract wild herbivores towards settlement, utilization of resources is incidental.	Management of water and other resources within PAs all year round.
2.		**An inevitable effect of increasing populations**	Population control by carefully calculated and controlled capture, culling or permitted hunting, castration and other methods.
3.		**Preference to crops over wild forage**	Alternative cropping, fences and deterrents. Reinducing human fear
4.		**Progressive loss of human avoidance behaviour due to the implementation of complete ban on hunting in India,**	Systematically designed strategic hunting/culling to re-instigate human avoidance behaviour.

b.

	Testable predictions
P1	Correlation between area under specific habitat such as forest cover and crop damage across area units.
P2	Correlation of crop damage with increase in canopy forest (or negative correlation with open patches/secondary forest/undercover within the habitats).
P3	Crop raiding only during migration, along paths. No return to refuge type of movement.
P4	Area covered by the invasive species should be correlated with the crop damage across time and/or area units.
P5	Crop raiding restricted to pinch period.
P6	Water management with parks arrests crop damage.
P7	Correlation between population estimates and crop damage across area units
P8	Crops have better nutritional quality; Choice experiments show preference to crop species over natural wild forage
P9	Wherever traditional hunting practices by communities are still prevalent, correlation with hunting
P10	Flight distance smaller near human habitation
P11	Destruction per unit farm area

c. NP = no specific prediction, +ve and –ve refers to correlations.

Hypothesis		**Testable predictions**										
		P 1	**P 2**	**P 3**	**P 4**	**P 5**	**P 6**	**P 7**	**P 8**	**P 9**	**P10**	**P11**
1.	A.	-ve	NP	NP	+ve	May be	NP	+ve	No	NP	NP	decrease
	B.	-ve	NP	Yes	NP	NP	NP	+ve	NP	-ve	NP	NP
	C.	NP	+ve	NP	NP	May be	NP	+ve	No	NP	NP	NP
	D.	NP	NP	NP	+ve	May be	NP	+ve	NP	NP	NP	NP
	E.	NP	NP	NP	NP	Yes	Yes	+ve	NP	NP	NP	NP
2.		NP	NP	NP	NP	NP	NP	+ve	NP	0 or -ve	NP	increase
3.		NP	NP	NP	NP	No	NP	+ve	Yes	NP	NP	NP
4.		+ve or 0	NP	NP	NP	No	NP	+ve or 0	Yes	-ve	Yes	increase