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Genetic erosion of crop landraces: trends in the conservation of locally adapted '*Newar*' radish in Jaunpur district, Uttar Pradesh, India

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A study was conducted to understand trends in the conservation of the locally adapted critically endangered radish landrace '*Newar*' (*Raphanus jaunpurensis* sp. *nova*.), conventionally grown in certain saline areas of Jaunpur city, Uttar Pradesh for use in *salads*, and for other traditional household uses, as well as the sale of fresh roots and seeds. An exploratory research design was adopted to collect data from 40 respondents, including 5 key informants. Specific agronomic characteristics of '*Newar*' such as long roots that maintained organoleptic properties for an extended time, salt tolerance, compatibility for mixed cropping with *hookah* tobacco, varied traditional usage and generation of extra income from the seed crop played a critical role in sustaining '*Newar*' radish cultivation in the past. Nonetheless, conservation and trade of this variety have collapsed over the past two decades due to a range of factors, including rapid urbanization, changing consumer preferences, gradually vanishing *hookah* tobacco cultivation and disappearance of the seed network. Concerted policy and scientific efforts are urgently needed to revive the cultivation of this unique horticultural resource.

Keywords: Agrobiodiversity, Landrace, Traditional knowledge, Salinity, *Newar* radish, Conservation

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Agrobiodiversity refers to the floral and faunal diversity actively managed by the farmers for direct or indirect use for food and other livelihood needs[1]. Additionally, agrobiodiversity reflects a range of invaluable ecosystem services; *inter alia*, regulating hydrological processes and microclimate, controlling soil erosion and mediating nutrient recycling[2,3]. Notwithstanding the critical role that agrobiodiversity continues to play in human sustenance, unabated erosion of agrobiodiversity is such that over 90 % of traditional crop varieties have disappeared over time[1] and many other important species and varieties are under threat of extinction[1,3]. These losses and the accompanying environmental degradation are adversely affecting the affordability and quality of food, particularly for marginalized communities across the world who still derive a significant part of their subsistence needs from wild, cultivated and community-managed plant resources[4]. Notably, the United Nations has declared the current decade (2011-2020), as the 'Decade of Biodiversity,' with the aim not only of preventing any further loss of biodiversity and degradation of ecosystem services, but of restoring at least 15 % of the world's degraded ecosystems by 2020[5].

Radish (*Raphanus sativus* L.; family Brassicaceae), a widely grown root vegetable, is believed to have originated in the eastern Mediterranean region. Wide genetic variability exists in radish with regard to the length (2 cm -1 m), diameter (≤ 60 cm), shape and colour of its swollen edible root[6]. In contrast to western countries where the radish root is largely used as a seasonal *salad* ingredient, it is deeply embedded in Asian culture and there is a great deal of diversity in the ways in which the radish plant is used[7]. As well as the roots being eaten fresh, they are processed into value-added products such as pickles, the leaves and roots are used as animal fodder and the seeds for oil extraction[8]. In the *Ayurveda* system of medicine, radish is used as a household remedy for treating ailments like jaundice, gallstones, liver diseases and indigestion[9].

Although human actions with regard to domestic-cation, agronomic manipulations[1] and community-led conservation[10] have been crucial to conserving contemporary agrobiodiversity, 'commercialization of

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agriculture' and 'globalization of food systems' are the two major processes that have, unintentionally, led to a rapid loss of locally adapted indigenous crop varieties. In most situations, replacement of the landraces by so-called 'improved" varieties, suited to intensively managed agricultural systems, is the main cause of genetic erosion[1,10]. Other anthropogenic drivers of agrobiodiversity loss include urbanization, changes in land use patterns and climate change impacts[10]. Traditional crop varieties conserved in subsistence farming systems constitute an invaluable and integral constituent of agrobiodiversity. Such *in situ* germplasm repositories are characterized by a continual and dynamic interaction among crop plants, wild relatives and the environment, resulting in potentially novel gene recombinations. In contrast, *ex situ* gene banks often represent only a fraction of genetic diversity and do not allow dynamic crop-environment interactions, thus halting key genetic evolution processes[11]. Despite detrimental effects of commercial agriculture on crop biodiversity in several parts of the world, individual and community-led efforts are still critical in conserving a wide spectrum of locally adapted crops and landraces[2,4]. A relevant example in this case is the '*Kyo-yasai*' system of conservation in the Japanese city of Kyoto. '*Kyo-yasai*' in Japanese means the heirloom varieties of vegetable crops conserved for thousands of years. Despite their high nutritive value and distinctive flavor compared to modern varieties, '*Kyo-yasai*' vegetables have lost their consumer appeal since the 1970s, threatening the existence of several such species including '*Sabaka-daikon*' (Japanese white radish) and compelling the local people and administration to make concerted efforts to revive their commercial cultivation[12].

A radish landrace called '*Newar*' or '*Jaunpur Giant*' has been grown in the Jaunpur district of Uttar Pradesh, India for a long time; especially in the urban areas situated on the left bank of Gomti river and some adjacent peri-urban villages. Except for a few print media reports branding '*Newar*' radish for its gigantic size vis-à-vis modern cultivars and hybrids[13-15], little attention has been paid to unraveling the trends in its traditional usage, desirable agronomic traits, nutritive value and conservation, which are nonetheless important to understanding the causes of its rapid depletion and to devising future conservation plans. Consistent with these facts, this study was carried out with the objectives: (i) to understand the trends in '*Newar*' radish conservation and utilization; (ii) to highlight the role of traditional knowledge and practices in sustaining '*Newar*' cultivation; and (iii) to delineate the causes of the rapid genetic erosion of this cultivar so as to suggest the appropriate strategies for its conservation.

Research methodology

Study site

This study was carried out in Jaunpur district lying in the subtropical Eastern Plain zone of Uttar Pradesh state. The district has a total geographical area of 4,038 sq km extending between latitudes 24.24°N to 26.12°N and longitudes 82.7°E and 83.5°E. The district is drained by five rivers of which two (Gomti and Sai) are the major rivers. Average annual rainfall is about 900 mm. The majority of the farmers are small and marginal landholders[16]. The soils are alluvial in origin and salt-affected to varying extent[17]. In general, the groundwater is safe for irrigation except at certain locations where it is marginally to moderately saline[18]. Diminishing soil health and fresh water, poor adaptive capacity of the local farmers and inadequate policy support are some of the major impediments to sustainable agricultural development in the district[16]. Rice, wheat, maize, pearl millet, pigeon pea and blackgram are the major *kharif* crops, while wheat, pea and chick pea are the main *rabi* crops. Sugarcane, fruits and vegetables are also grown in a sizable area[16,18].

Sampling design

This exploratory research was conducted using an inductive approach. Being a native of the study district, the first author was acquainted with the cultivation of the '*Newar*' radish landrace since his childhood. After becoming aware through newspaper readings of the fact that the '*Newar*' landrace faces the threat of extinction, he discussed this issue with RKS as to what could be done to save this unique landrace. Both of them, in successive meetings, decided that current trends in conservation and utilization of '*Newar*' first need to be delineated before a future course of action is determined. Accordingly, based on preliminary information published in newspapers and other secondary sources, a systematic study was planned and carried out, from January, 2016 to August, 2017. Considering the fact that '*Newar*' was grown only in certain areas of Jaunpur city and some adjoining villages (Baluaghat, Mandi Naseeb Khan, Tadtala, Makhdoom Shah Adhan, Mulla Tola, Paan Dariba, Mufti Mohalla,

Dera Yusuf, Khasanpur, Bhaurajipur, Kuttupur, Haidarpur and Harakpur), these areas were surveyed to identify the respondents and key informants directly or indirectly associated with recent '*Newar*' cultivation. Based on the insights from this survey, a total of 40 respondents were selected through a snow-ball sampling method. These included 15 individuals (40-70 yrs) having indirect experience with '*Newar*' use and the remaining 25 respondents (including 5 key informants) being directly associated with '*Newar*' cultivation in the past. The two sets of respondents (15 and 25, respectively) were interviewed in order to determine 'general trends in *Newar* production and availability' and 'specific aspects of *Newar* cultivation and conservation', respectively.

Data collection

Using information generated during the preliminary discussions, a semi-structured interview schedule was developed with a set of questions in the Hindi language related to agro-ecological knowledge and agronomic practices, biocultural dimensions and the current status of '*Newar*' radish conservation. The schedule was pilot tested and ambiguous questions deleted before the interviews were conducted. To help understand the micro-climatic features of croplands where '*Newar*' was previously grown, transect walks with a few farmers were conducted. Furthermore, one transect walk was also carried out with Jiyalal Maurya (JLM), a farmer who still conserves '*Newar*', to observe the crop growth in field and to acquire knowledge about agronomic practices. The insights gained from the personal interviews and transect walks were combined with secondary data from web resources, grey literature, news clips and peer-reviewed articles. Focus group discussions were also conducted at the sampled sites to understand the conservation dynamics in '*Newar*' and other local crops. As well, a detailed analysis of land use patterns using the satellite data was carried out to understand land use trends in Jaunpur city from 1991 to 2016. To quantify the changes in the flow of the Gomati river and its probable influence on the hydrology of the adjacent flood plains where '*Newar*' was grown, LANDSAT-7 satellite imageries from 1991-2016 were also accessed and interpreted[19]. The reduction in the river width and floodplain area, and the concomitant increase in the settlement (built-up) area were calculated from the images. Key results of this study were shared and discussed with the conservator(s) and the past growers of '*Newar*' to validate the findings and help draw conclusive inferences. Prior informed consent was obtained from all the respondents to report their knowledge through publication.

Data analysis

The qualitative data were thematically coded and triangulated to determine patterns and trends in '*Newar*' production. The data were entered into an excel spreadsheet for analysis using descriptive statistics such as frequency, mean and percentage. Tables and graphs were developed to summarize the results. Both qualitative and quantitative data (farmers' socio-economic profile, urbanization trends, etc.) were integrated to reach to conclusive evidence.

Results and discussion

Plant description

'*Newar*' is a critically threatened radish landrace endemic to the Jaunpur district of Uttar Pradesh. It seems to have been grown since time immemorial in specific pockets of Jaunpur city in the close proximity of Gomti river. It was previously thought to be a subtaxon of *R. sativus* but a recent taxonomic study revealed that it is a new species: *Raphanus jaunpurensis* Masood Akhtar, SV Singh & RC Srivastava, ssp. *nova*. This species differs from *R. sativus* in important plant growth characteristics. '*Newar*' plants can attain a height of 180 cm or more. The taproots are white and cylindrical. Root length and circumference can be ≥ 210 cm and up to 75 cm, respectively. Root weight up to 56 kg has been recorded. The flowers are white in colour and borne in racemes. The seeds are dull in colour and smaller than those of *R. sativus*[20]. A view of crop and fully grown edible roots is given in Fig. 1.

Fig. 1 — '*Newar*' conservator Shri Jiyalal Maurya presenting an edible root to District Magistrate, Jaunpur, Uttar Pradesh (a) (Photo: Shri Ravi Maurya, Mandi Naseeb Khan); '*Newar*' crop in partially reclaimed sodic soil (b) and an edible root produced in a farmer participatory trial (c) (Photo: Anshuman Singh).

Historical perspective

Although the time of origin of '*Newar*' cultivation is unknown, some evidence suggests that its domestication may extend back to the medieval period (c. 14th century AD), at a time when Jaunpur was an independent sultanate under Sharqi rulers. One of the respondents in this study [Ram Asre Maurya (RAM)] recounted a legend in which two cultivars of radish, viz. '*Newar*' and '*Maar*', were evidently introduced from Kannauj. The historical and cultural relations between Jaunpur and Kannauj districts, located approximately 400 km apart, support this assumption. First and foremost, the western frontier of Jaunpur Sultanate under Sharqi rulers extended to Kannauj[21]. Second, until recently both of these districts harboured a flourishing perfume industry based on the commercial production and distillation of rose[22] and jasmine[23] flowers. Third and most important, a similar radish landrace, called '*Kannauji*', has also been reported from Kannauj[24]. These observations support the assumption that crop germplasm movements and exchanges between these two centres were common during medieval times. All of the respondents in our study agreed that '*Newar*' radish was a common kitchen garden plant in most parts of the old Jaunpur city. About 40 % of the respondents recalled that '*Newar*' was also cultivated in the peri-urban villages, most of which have now become a part of Jaunpur Municipal Council. Almost all of the respondents (96 %) lamented that '*Newar*' cultivation gradually came to a standstill for about 15 yrs, c. late 1980s and early 1990s. One of the key informants, RAM, recalled that the best quality radish roots were produced at locations around '*Nawab Sahab Ka Hata'*, an important landmark in the old city, where saline groundwater was used for irrigation. He added that the presence of salts in the water did not adversely affect the root yield or quality of '*Newar*'. This proposition was also echoed by JLM, another key informant and a '*Newar*' conservator (Fig. 1a), who maintained that roots irrigated with saline water had better organoleptic properties than those receiving fresh water. Environmental factors such as relative humidity (RH) greatly modulate the degree of salt tolerance in radish such that a particular genotype growing at high RH (90 %) may exhibit about fourfold higher salt tolerance than when grown under dry conditions (45 % RH)[25]. Although yield declines are common in saline soils, certain radish cultivars exhibit only marginal reductions in plant dry weight up to 9 dS m^{-1} salinity[26]. These observations lend support to a genotype- and micro-climate specific salt tolerance in '*Newar*' grown on the relatively humid flood plains of Gomti river.

Salt tolerance

Based on the inputs of key informants, available literature was surveyed to obtain further evidence on *Newar*'s salt tolerance. It appears that moderate salinity in the root zone could be one of the prerequisites for its optimum growth. In all, 45 % of the respondents said that this crop responded favourably to brackish water irrigation. They, however, added that partial reductions in root yield were observed in relatively heavy textured soils. Another observation is that root length, girth and biomass of '*Newar*' are generally 2.5 times higher under saline conditions compared to normal soils[27]. This can partly explain why root growth considerably declined when '*Newar*' was recently grown at some distance from the traditional growing areas in the city. Studies have been conducted to ascertain whether location and salinity level, specifically, can affect the growth of '*Newar*', other factors remaining the same. The results showed that the roots were considerably longer and thicker at Bhavrajipur and Mandi Naseeb Khan, two locations in vicinity of the Gomti river (and both within our study region), compared to those produced at Siddiquepur, situated at some distance from these locations. A key difference between these locales lay in the salinity of soil and water. Soil (EC_e) and irrigation water (EC_{IW}) salinities at the former two sites were nearly threefold higher than at Siddiquepur[28]. It has been shown that '*Newar*' roots harbour plant growth promoting rhizobacteria which produce growth hormones like auxin, solubilize the soil phosphorus and produce siderophores, all of which might contribute to enhancing the salt tolerance[29]. As a corollary, efforts were made to obtain '*Newar*' seeds in order to test them in salt-affected soils (Figs. 1b&c). One of the key informants, JLM, who still conserves '*Newar*' in his kitchen garden, provided the seeds for evaluation in salt-affected soils. Anticipated success in this direction can address the intertwined objectives of identifying a potentially novel salt tolerant cultivar for augmenting the farm incomes in saline areas, and generating seeds of this rapidly disappearing cultivar.

Farmers' agroecological knowledge

The respondents unanimously agreed that freely draining sandy loam soils were best suited for

'*Newar*' cultivation. The crop was raised either in city areas for fresh roots or in the adjoining villages for commercial seed production. Seeds of this root crop were sown from the second fortnight of September to the first week of November. However, a majority (70 %) of the respondents indicated the second fortnight of October to be the optimum time of sowing. '*Newar*' crops sown around '*Vijaya Dashmi*' festival produced the best quality roots. While one key informant, JLM, said that seeds harvested from the previous season gave the best results, others including RAM and Lalji Maurya (LM) opined that planting 2-3 yrs old seeds resulted in better quality roots, and noted that '*Newar*' seeds remained viable even up to 8 yrs:

'Aath murai, nau chaurai, barah barish bathua k aai'

[Seeds remained viable up to 8 yrs in *Newar*, up to 9 yrs in amaranth (*Amaranthus* spp.) and up to 12 yrs in lamb's quarter (*Chenopodium album* L.); LM]

The informant JLM said that mixed cropping of *hookah* tobacco (*Nicotiana tabacum* L.), *palak* (*Spinacia oleracea* L.) and radish was predominant until recently: tobacco was the main crop and both spinach and radish were the subsidiary crops. Regardless of length of the beds, approximately 2 m wide beds were prepared for sowing tobacco and spinach. About 20-30 cm high ridges were made between two beds for radish sowing. Before sowing, the fields were prepared using bullock-drawn plough and leveler followed by the application of farmyard manure as available. About 85 % of the respondents informed that they also applied neem cake, an organic pesticide derived from the neem tree (*Azadirachta indica* A. Juss.), usually every year, to suppress the pests and diseases. In fact, fields were prepared and manured for the tobacco crop and no specific agronomic operations were separately carried out for radish growing, except the inter-cultural operations at the later stages of crop growth. About 70 % of the respondents said that production of the best quality tobacco leaves necessitated utmost care in nutrient management and irrigation (regularly at 8-10 days intervals), and these same soils, in turn, equally nourished the '*Newar*' crop. Depending on the date of sowing, the roots were harvested between mid-November to mid-January for consumption and sale. Mixed cropping of spinach, '*Newar*' radish and tobacco provided a staggered source of income spread over a six-month period: spinach leaves were sold during mid-November to mid-December, radish roots during December to January and a bulk of income was generated from the sale of tobacco leaves in April.

The unmarketable surplus roots were used to plant the seed crop over the entire field at 0.45-0.6 m row to row and plant to plant spacing. Majority of the farmers in the adjacent villages procured such roots from their city counterparts doing away the need for nursery management. The roots were cut in two halves and the top 40-50 % portion was used for planting the seed crop. Depending on the date of planting, the crop was harvested in the last week of March to mid-April. At maturity, the crop had a height of about 1.5-2.0 m. Only the upper (~0.5 m) pod-bearing portion was cut, left in the field for drying and then threshed on a clean surface. LM said that seed yield ranged from 1.5-1.8 t ha^{-1} and dropped below 1.0 t ha^{-1} if the crop was severely affected by mustard aphid. It also emerged that seeds obtained from the root crop were less vigorous while those obtained from the planted crop had high seed vigour and germination.

Traditional usage

Fresh roots and seeds were the main economic parts of cultivar '*Newar*'. Consumption of fresh roots, cut into small pieces, as *salad* was the most predominant use. About 40 % of the respondents said that consumption of puffed grains, mainly pop corn, along with radish and a pinch of salt was considered a delicacy. All the respondents opined that even the fully developed '*Newar*' roots remained tender and sweet, a desirable agronomic trait that needs to be investigated in greater detail as overgrown roots in commonly grown radish varieties are pithy and bitter[30]. During '*Makar Sankranti*' festival (called *khichdi* in the local dialect), usually falling on 14th January, it was customary to send radishes along with other items like flattened rice (*Oryza sativa* L.) (*chura*), *til* (*Sesamum indicum* L.) laddu (*tilkut*), sweets and clothes to the married daughters and sisters. In fact, the *khichdi* basket devoid of radishes was considered incomplete. All the respondents agreed that tradition of sending radishes symbolized a cultural connection as reported elsewhere[4]. They further added that this period (mid January) also coincided with the peak market demand for the fresh roots prompting the growers to plant an early crop to fetch remunerative prices[15]. Radish pickle was the main value added product, prepared by washing,

drying, peeling and cutting the roots into small rectangular pieces. About 3-4 tablespoons of common salt are added per kilogram of radish. The tray containing pieces of radish root is placed under direct sunlight in a standing position so that water can freely move downwards. Fenugreek and *ajwain* seeds are roasted in oil till they turn brownish. The roasted seeds are cooled and ground along with *rai* seeds into a coarse powder. Now, completely dry radish pieces are fried in hot mustard oil for 3-4 min followed by the addition of asafoetida, turmeric powder, red chilli powder and salt to taste. Roasted seed spices are then added and the mixture is properly blended, stored in a container and put under sunlight for about 4 days. Almost all the respondents said that pickle is still prepared from other radishes but is far less tasty than that prepared from '*Newar*'. Another important value added product was the sharp-tasting 'radish salt'. The fully grown roots are washed, cleaned, cut into pieces and burnt on a smooth clean surface. The ash is dissolved in water and put in a boiling pot to obtain the white salt to be used as a homemade remedy for quick relief from stomach ailments such as constipation. Seeds which remained unsold or were surplus to that required for sowing the next crop were used for extracting oil that would solidify at the room temperature resembling other vegetable fats. Seed oil yield of '*Newar*' is slightly higher compared to mustard. The oil was used to fry '*poori*' a popular local cuisine made from wheat flour. Compared to other vegetable oils, *pooris* fried in *Newar* oil are softer and crispy. Seed oil was considered to be an effective herbal medicine for skin problems like psoriasis and dermatosis. Some '*Newar*' conservators (*e.g*., JLM) still display the roots during agri-exhibitions organized at the district headquarters to showcase their efforts in conservation and to sensitize the administration and the people about this cultural heritage.

Trade in roots and seeds

Most of the respondents informed that both fresh roots and seeds were traded, both locally and regionally. Nonetheless, bulk of fresh produce was sold at the local vegetable market with first fortnight of January being the time of maximum demand from the local buyers. JLM recalled that besides local vendors even vegetable traders from other districts frequently visited the *Newar* growers during the peak production period. He added that local contractors also used to collect the radish roots at the Jaunpur Railway Junction from where it was presumably transported to other districts. Radish seed was another major item of trade. Many local shopkeepers specifically dealt with *Newar* and seeds of other locally important vegetable crops. Unfortunately, the flourishing seed trade gradually vanished due to lack of attractive prices and government support. It appears that growers exclusively focused on the root and seed business and no attempts were made to popularize and market the value-added products like pickle and seed oil that could have provided a sound footing to '*Newar*' cultivation. Locally traded minor crops are mostly destined to be ill-fated in the long run[31].

Causes of rapid loss of *Newar*

An overwhelming 84 % of the respondents opined that rapid urbanization has been the most severe setback to its continued existence (Fig. 2). They noted that gradually diminishing land availability has, in general, led to a considerable reduction in area under vegetable crops in most parts of the city. Census data show that population density (people per sq km) of Jaunpur district increased by about 15 % over 2001-2011[32]. Unabated urbanization could usurp nearly 2 % of the highly productive global croplands by 2030[33]. Pervasive land use accelerates biodiversity erosion and land degradation[34]. Satellite data showed that the floodplain area of the Gomti river, where most of the '*Newar*' crop was grown, has considerably shrunk over the last few decades. The river area and the floodplain area have reduced by about 19.34 % and 55.12 %, respectively, with a concurrent increase of

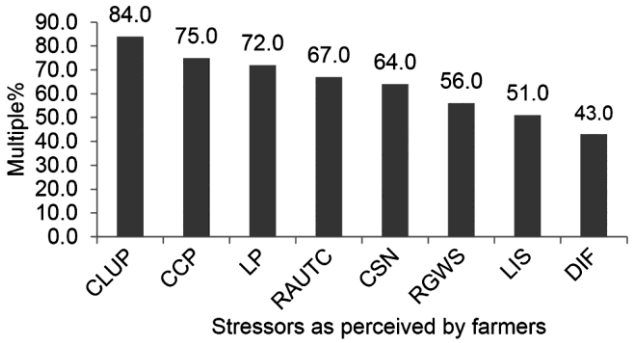

Fig. 2 — Reduction in area under '*Newar*' radish caused by various stressors

Abbreviations: CLUP= Changes in land use pattern; CCP= Changing consumer preferences; LP= Less profitability; RAUTC= Reduction in area under tobacco crop; CSN= Collapse of seed network; RGWS= Reduction in groundwater salinity; LIS= Lack of institutional support; DIF= Declining interest in farming

Table 1 — Change in the land use pattern of Gomati river and adjoining floodplain area where *Newar* radish was grown

Years	River area	% decrease	% change	Floodplain	% decrease	% change	Settlement	% increase	% change
1991	1.179	--	--	4.031	--	--	25.328	--	--
2001	0.951	80.66	19.34	2.222	55.12	44.88	35.088	138.54	38.54
2016	0.808	68.53	31.47	1.667	41.35	58.65	37.581	148.38	48.38

Source: (19)
Note: The percentage of decrease or increase over a period of time was calculated based on the base year 1991.

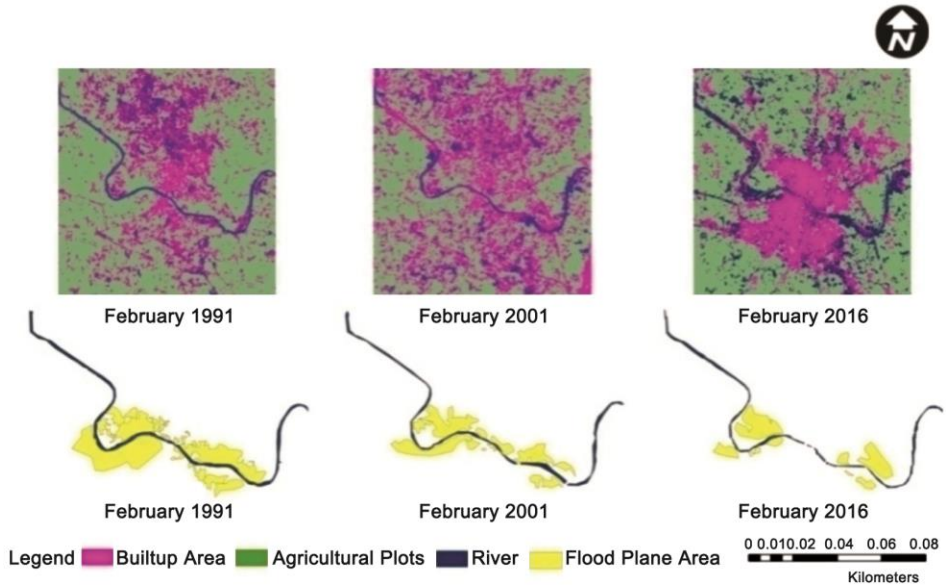

Fig. 3 —Trends in temporal flow pattern of Gomati River, and changes in flood plain and adjoining human settlement areas where '*Newar*' radish was earlier grown

over 38.54 % in the settlement (paved area) area over 1991-2001 (Table 1, Fig. 3). Further change occurred in river and floodplain area was 31.47 % and 41.35 %, respectively during 1991 to 2016. Whereas the percentage increase in settlement area occurred by 48.38 %. A strong majority of the respondents (75 %) said that there has been a sea change in the consumer preferences for the radish; especially with regard to root length and the people increasingly prefer small sized roots. This, coupled with less profitability in *Newar* cultivation (72 % respondents), compelled the growers to switch over to other remunerative vegetable crops like cabbage, cauliflower, garlic, leafy greens, turnip and beetroot. Of late, release of a large number of radish varieties by private seed companies has further accentuated the problem[35]. Continued decrease of tobacco acreage seems to have caused collateral damage, albeit unintentional, to radish cultivation (67 % respondents). It is worth mentioning that *hookah* tobacco was a major item of trade until 1990s for the local farmers. Of late, considerable increase in cigarette smoking among both rural and urban populations[36] has led to a severe drop in *hookah* tobacco demand compelling the tobacco growers to explore other viable options for their livelihoods. Although *hookah* tobacco (locally called *patte ki kheti*) is still grown by some farmers, *Newar* is rarely intercropped and has been replaced by more remunerative crops like garlic. Together, these changes had a devastating impact on the local seed network (64 % respondents), which eventually disappeared. There is evidence that unrestricted exchange of seeds between farmers is crucial to farmer-led conservation of agrobiodiversity[37].

Over 50 % of the respondents emphasized that a lack of institutional support and declining interest of youth in farming seems to have further compounded the problem. Some of the respondents said that groundwater salinity has subsided in areas where '*Newar'* crop was grown leading to appreciable reductions in root length and quality. Respondents said that they never received any policy support to sustain '*Newar*' cultivation, a fact also substantiated

by the media reports[14,15]. In addition to '*Newar*' radish, Jaunpur has acquired a reputed position for the cultivation of an array of locally adapted crops and landraces including an early maturing, water logging tolerant maize landrace called '*Jaunpur Local*', scented rose and jasmine, betel leaf, pointed gourd and a muskmelon landrace called '*Jaunpur Netted'*. Most of these crops have been conserved and grown by the subsistence farmers. Importantly, many of these crops constitute a symbol of cultural identity for the local communities: '*Koeri*' and '*Chaurasia*' communities still identify themselves as the custodians of vegetable crops and betel leaf, respectively. Unfortunately, these stress resilient and locally traded 'orphan crops'– an expression of biocultural diversity – have received meagre research and investment attentions, as is the case with several minor crops across the world[31], leading to diminishing interests of the local farmers in their cultivation. Results indicated that production of quality '*Newar*' roots required utmost dedication, starting from the field preparation. Delicate care was needed for timely irrigation and weeding. The present generation has become less interested in farming in general and *Newar* cultivation in particular. Bullock-drawn ploughs have been replaced by the tractor-operated cultivators. Root crops need diligent care in field preparation and deep tillage is necessary to prevent the formation of hard pans in the soil. Repeated ploughing by a cultivator seems to have created a sub-surface compact layer less conducive to '*Newar*' crop growth[38].

Conclusion and policy implications

It is concluded that the radish landrace '*Newar*' has considerable agroecological (*i.e*., higher salt tolerance) and biocultural (*i.e*., traditional household uses and livelihood support to the farmers) values. Although direct evidence is lacking, its critical ecosystem services like conservation of pollinators and role in species diversity should also be considered. Efforts are underway for the proximate nutritional composition of fresh leaves, roots and seed oil to understand their potential health benefits. Multi-location farmer participatory trials in salt-affected areas and on-station experiments are being conducted that could provide insights into possible adaptive mechanisms of '*Newar*' under marginal conditions. Efforts are also being made for its Distinctness, uniformity and stability (DUS) characterization and inclusion in the National Seed Bank. Genes linked to desirable agronomic traits such as salt tolerance and large, crisp, flavourful roots need to be identified for future use in genetic improvement programmes. Substantial and concerted scientific efforts and policy support are needed to revive '*Newar*' cultivation. The people still conserving '*Newar*' need to be rewarded and incentivized under agrobiodiversity conservation policies such as the 'Plant Genome Saviour Farmer Reward' of the Protection of Plant Varieties nd Farmers' Rights Authority (PPV&FRA), India. A need is felt for ecosystem-base adaptation models for promoting '*Newar*' conservation in a socially acceptable manner. Awareness campaigns are necessary to sensitize different stakeholders about the multifarious benefits of this traditional horticultural resource.

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