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Mistranslating refuge crops: analyzing policy mobilities in the context of Indian Bt cotton production

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Abstract. In light of recent pink bollworm (PBW) pest infestations in several cotton-producing states in India, farmers of genetically engineered Bt cotton (Bt for *Bacillus thuringiensis*) have faced fierce criticism for their noncompliance with the national insect resistance management (IRM) strategy. We argue that this criticism is short-sighted and one-dimensional. Building upon the literature on policy assemblages we show that the implementation of the IRM strategy in India was seriously flawed due to government-induced mistranslations of foreign strategies in the form of policy-diluting alterations. We first show that India's IRM strategy differs substantially from successful strategies pursued in the USA or China. Second, we present results from a representative survey in the state of Telangana ($n = 457$) and show that India's IRM strategy neglects moral economic considerations and entrepreneurial agricultural logic that Indian cotton farmers strive for. We conclude that pink bollworm pest infestations in India are not the fault of farmers but rather the result of a mismanaged biotechnology project undertaken by the Indian government and its associated responsible ministries.

1 Introduction

In the production of genetically engineered Bt cotton (Bt for *Bacillus thuringiensis*), the planting of refuge crops (*refugia*) is the primary insect resistance management (IRM) strategy adopted worldwide to delay the evolution of lepidopteran insects to becoming resistant to the toxin produced by the Bt crop; thus, this has become the prevalent policy measure recommended by seed producers and authorities. However, since lepidopteran (i.e., pink bollworm, PBW) pest infestations have recently returned in several cotton-producing states in India, the planting of these refugia has become the "Achilles" heel of Bt cotton in the country (Mohan, 2018). While the pest had recently been declared eradicated in the USA (USDA, 2018; Tabashnik and Carrière, 2019) and had been successfully repressed in China (Wan et al., 2017; Tabashnik and Carrière, 2019; Wang et al., 2019; Tabashnik et al., 2021), widespread resistance to the Bt cotton target pest has been reported in central and southern Indian cotton-producing states, such as Gujarat, Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh, and Telangana (Mohan, 2017; Naik et al., 2018; Fand et al., 2019; Najork et al., 2021, 2022). Since the majority of farmers in India do not comply with instructions to grow mandated refuge crops (Mohan, 2017; Tabashnik and Carrière, 2019), public authorities and industry representatives have blamed farmers for (unknowingly) causing the biotechnology of Bt cotton to fail (ISAAA, 2017). In this paper, we argue that blaming farmers for their noncompliance is short-sighted and one-dimensional, as it neglects the moral economic embeddedness of farmers and the responsibility of Indian state authorities embodied by the Department of Biotechnology (DBT) and the Ministry of Environment, Forest and Climate Change (MoEFCC) as well as associated responsible committees.

We build upon the literature on policy assemblages to show that the implementation of the IRM strategy in India has involved serious mistranslations. The literature concerned with policy assemblages replaces concepts of knowledge transfer and diffusion with the notions of translation and mutation (e.g., Peck and Theodore, 2010; Peck, 2011). We extend this discussion by focusing on the rural context of India (Keck, 2019; Najork et al., 2021, 2022) and show that policy mobilities need to consider local adaptations pursued by actors "on the ground".

In the first step of our analysis, we build upon the approach of "following the policy" (Peck and Theodore, 2012; Prince, 2017; McCann and Ward, 2013) and highlight the contextual twists and turns that IRM regularities have undergone while being adapted to India. In doing so, we show that India's failed IRM strategy differs substantially from the strategies pursued in the USA and China. As examples of successful policy implementation and pest control, the IRM strategies of the latter two countries, which together with India are the three leading countries in global cotton production, were selected for comparison in this study for two reasons: first, they serve as contrasting counter-images to India's failed policy implementation. Second, Indian authorities indicated the aim to follow their examples in terms of IRM strategies.

In the second step of our analysis, we move to the side of designated policy implementation by presenting results from a representative survey in the state of Telangana ($n = 457$), including bivariate analyses and a multivariate cluster analysis. In this step, we revert to previously gathered qualitative data to contextualize our quantitative findings in the respective local setting. In this regard, we draw on moral economic considerations, which have hitherto been overseen in the critique formulated by Indian state authorities and industry representatives. We thereby expose the role of the Indian state, embodied by the responsible ministries and committees, in being accountable for involved mistranslations. The overall aim of our study is to explore the information that is being lost in the manifold translation processes inherent in India's IRM strategy and to challenge the dominant narrative claiming that farmers are responsible for the failure of Bt cotton.

2 Policy studies: from policy transfer to policy assemblages, mobilities, and mutations

To disentangle the translation nexus of refuge policies in the context of genetically engineered organisms (GEOs), we revert to the body of literature engaged in *policy assemblages, mobilities, and mutations* (Peck and Theodore, 2010; Peck, 2011; McCann and Ward, 2013; Stone, 2012, 2017; Prince, 2017), which builds upon and extends the notions of policy transfer and diffusion (e.g., Dobbin et al., 2007).

The concept of *policy transfer and diffusion* is rooted in orthodox political science but is an "intrinsically geographical" approach (Peck, 2011, p. 774). Due to neglecting the variegated social, relational, and territorial contexts of policy activities, the idea of policy transfer has faced increasing criticism (Peck, 2011; McCann and Ward, 2013; Prince, 2017). Critics claim that policy transfer lacks attentiveness to the complexity of policy translation nexuses, as it relies upon the presumption of a linear and straightforward transferability of intact policy models, usually in the form of best practices and direct lesson drawing (Peck and Theodore, 2010; Stone, 2017). As a result, it fails to consider the relational dynamics of policy making and the possibility of policy modification, transformation, or failure (Peck and Theodore, 2010; Stone, 2012). It is therefore unable to do justice to messy interpretative realities and falls short in terms of addressing political interests or asymmetrical power relations (Peck, 2011; Stone, 2012).

Inspired by and aiming to address these criticisms, the approach of policy assemblages, mobilities, and mutations emerged from the interdisciplinary field of critical policy studies (Prince, 2017; Savage, 2020). This approach is "attentive to the [constitutive] sociospatial context of policy-making activities" (Peck, 2011, p. 774; Peck and Theodore, 2010). It recognizes that policies can hardly be transferred directly and linearly and that policy formation and transformation, being constituted by predominant power relations, must be understood as social, relational, and territorial (Cochrane and Ward, 2012). The idea of policy mobility and mutation, rather than transfer, entails the notion of a more dynamic, complex, and power-laden constitution of policy translation processes and networks that "involves a wide range of practices and sites" (McCann and Ward, 2013, p. 9). It is emphasized that policies morph and mutate throughout their journeys and do not arrive as complete packages but instead "move in bits and pieces" and are thus constantly reshaped (Peck and Theodore, 2010, p. 170).

Policy translation therefore not only encompasses a "straightforward copying of policy" but rather entails a broad spectrum of objects and modalities of transfer (Stone, 2017, p. 4). The resulting spectrum of policy adaptation underlines the active construction and reassembly of policies and their implementation through policy actors on a local level (Stone, 2017; McCann and Ward, 2013). Policies are thus constantly reshaped at the local site of adoption throughout the process of mobilization.

Not only are policies locally shaped, but they also shape places in turn. Peck and Theodore (2010, p. 170) emphasize that "mobile policies, then, are not simply traveling across a landscape – they are remaking this landscape". The two authors thus argue that "all policies are local" (Peck and Theodore, 2010, p. 170). Cochrane and Ward (2012, p. 4) provide reasoning as to why this "localization" occurs; hence, policies cannot be transferred straight from point a to point b "because they emerged from and are responses to particular 'local' sets of social and political conditions which are not replicated in the places to which they are transplanted".

This post-transfer conceptualization of mobility and mutation has lately been fruitfully stimulated by concepts of policy assemblage that originated from Deleuze and Guattari (1987) and are related to Latour's (2005) actor–network theory (ANT) (Latour, 2005)[1]. The approach views policy

[1]Methodologically, for example, the Latourian follow-the-thing concept from ANT has been adapted to policy studies in the form of follow the policy (Peck and Theodore, 2012).

translation as an actively constituted rather than statically arranged ensemble. This ensemble is relationally assembled through practices and stresses the perspective of spatiality (McCann and Ward, 2013; Prince, 2017; Savage, 2020). As such, it helps to "think policy mobility beyond the local–global binary" and instead argues that the global and the local are produced in the (policy) assemblage (Prince, 2017, p. 336; Keck, 2019). Policy translation is thus understood as a complex social process entailing morphing fragments – not as the transfer of immutable things (McCann and Ward, 2013, p. 8).

In the following, we aim to apply the approach of policy assemblages, mobilities, and mutations to the Indian context of Bt cotton refuge policy authorization and implementation. For this endeavor, we follow the policy (Peck and Theodore, 2012) from the national level of its first authorizing administrations (USA and China) to India. We map out the mutations and mistranslations the policy has undergone in its mobility due to administrative alterations. We then follow the policy further to its local sites of implementation on Indian cotton farms by demonstrating that Indian administrative authorities have not sufficiently taken the local realities of Bt cotton farmers into account to successfully put the IRM strategy into practice.

3 Following the policy to India

By following the perspective of policy assemblages, we now show that India's IRM strategy differs substantially from the successfully pursued policies in the USA and China, leaving Indian farmers as the only remaining group of actors responsible for repressing the evolution of resistances in the abovementioned pink bollworm population. In the following, we thus briefly sketch the initial refuge policies of the USA and China before outlining the Indian policy adaptations in more detail.

3.1 The background of Bt cotton refuge policies

Equipped with genes of the Bt bacterium, Bt cotton produces endotoxins that are lethal to lepidopteran insects and thus creates inbuilt pest resistance for the Bt crop (Kathage and Qaim, 2012; Kaviraju et al., 2018; Naik et al., 2005). Originating from concerns about evolving resistance in lepidopteran insects and therefore aiming to enhance the technology's longevity, IRM strategies were developed by academic, industrial, and regulatory experts[2] (Head and Greenplate, 2012; Tabashnik et al., 2021). In the production of Bt cotton, the planting of refuge crops is the primary IRM strategy adopted worldwide to delay the evolution of insect resistance to the genetically engineered (GE) crop (Tabashnik et al., 2021; Mohan, 2018, 2020; Kranthi et al., 2017). Areas of refuge crops consist of non-Bt cotton plants that are cultivated near the Bt cotton field to allow for the reproduction of the target insects without evolutionary pressure imposed by the Bt toxin (Mohan, 2018). Based on population genetic theory, this strategy assumes that inheritance of resistance is recessive; when the Bt-susceptible larvae produced through the refuge mate with the nascent Bt-resistant moths emanating from Bt cotton crops, their offspring should again be susceptible to the endotoxins so that in the end resistance in the insect population to the Bt crop remains negligible (Gould, 2000; Mohan, 2018, 2020; Tabashnik et al., 2021).

3.2 The US refuge policy

Similar to the implementation of Bt cotton itself, the adoption of the concomitant refuge policy was first introduced to the USA in 1996 (Tabashnik and Carrière, 2019). Today, the country is the third-largest producer (after India and China) and the largest exporter of cotton (USDA, 2020b). The crop is predominantly grown in the "Cotton Belt" of 17 southern-tiered states, and its production in the country is characterized by a high degree of mechanization (USDA, 2020b). The average cotton farm size covers 1312 acres (approx. 530 ha), and average yields amounted to 2712 kg ha^{-1} (seed cotton) in 2019 (FAO, 2021; USDA, 2007). US cotton farmers are protected through crop insurance and risk-management programs from yield loss (e.g., weather-related) (USDA, 2020b).

The Bt cotton-related refuge policy was stipulated by the Environmental Protection Agency (EPA) under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (Frisvold and Reeves, 2008). Cotton growers largely complied with the decreed policy that required a non-Bt cotton refuge area of 25 %, so from its authorization in 1996 until 2005, > 25 % of the area planted with cotton was comprised of non-Bt cotton planted in blocks or rows separate from the Bt cotton field ("structured refuge") (Tabashnik et al., 2012, 2021). This policy measure was followed by a multitactical collaboration program from 2006 to 2014. This included releases of billions of sterile pink bollworm moths susceptible to the Bt toxin from airplanes in the southwestern USA and northern Mexico, which were intended to mate with Bt-resistant moths (Mohan, 2018; Mohan and Sadananda, 2019; Tabashnik et al., 2010, 2012, 2021; Tabashnik and Carrière, 2019). As the remaining progeny were supposed to be exposed to the highest possible dose of Bt toxins, refuge measures were abandoned entirely, thus exclusively leaving Bt cotton expressing the relevant endotoxins (Tabashnik et al., 2021). No pink bollworm moth was detected in US cotton fields from 2013 to 2018; hence, the pest has recently been declared eradicated (USDA, 2018; Tabashnik and Carrière, 2019) (Fig. 1).

[2] In this study, we follow the Bt cotton-related IRM policy from the national administrative level to the local farm level. We also deem the role of seed producers to be vital in the process of policy crafting. However, as we focus on the national level of policy formulation and the local level of policy implementation, we leave the intermediate level of the seed industry as a promising topic for further research.

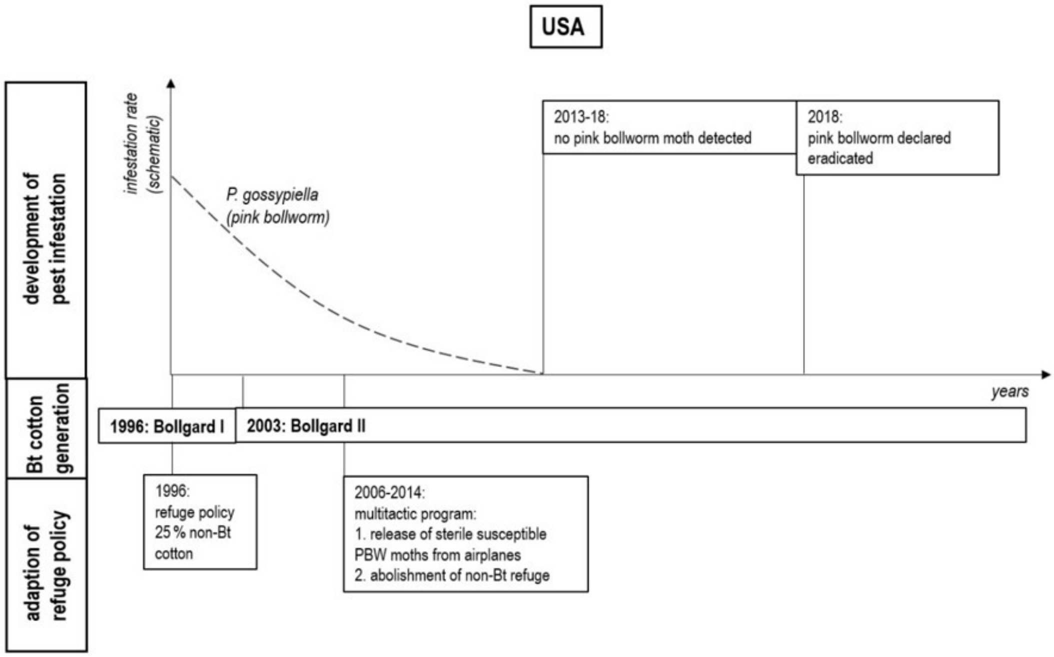

Figure 1. Refuge policies and pest development in the USA.

3.3 The Chinese refuge policy

Chinese cotton production is mainly located in the region of Xinjiang and the valley of the Yangtze River, where the crop is grown predominantly by small-scale farmers, with small-scale cotton holdings averaging 534–800 m^2 per farm holder (Stone, 2007; Du, 2012, quoted from Dai and Dong, 2014; Wan et al., 2017; Wang et al., 2019). Despite the low degree of mechanization, Chinese cotton yields of 4812 $kg\,ha^{-1}$ (seed cotton) in 2019 clearly exceed the world average due to a series of labor- and chemical-intensive farming technologies and cultural practices (Dai and Dong, 2014; FAO, 2021). Unlike most other countries, China introduced the first generation of Bt cotton in 2000 without mandating a non-Bt cotton refuge and instead merely relied upon "natural refuges" consisting of noncotton crops such as pigeon peas (Jin et al., 2015; Tabashnik and Carrière, 2019; Wan et al., 2017). While this strategy maintained the levels of polyphagous lepidopterans, i.e., pests that are not exclusively feeding on cotton, such as American bollworm (*Helicoverpa armigera*), low, rising resistance levels were observed for the monophagous pink bollworm, which feeds exclusively on cotton, from 2008 to 2010 (Tabashnik and Carrière, 2019; Wan et al., 2017; Wang et al., 2019). However, contrary to the expectations of experts who anticipated further increases in pink bollworm infestation, the respective levels fell again from 2011 to 2015, and resistance was reversed (Tabashnik and Carrière, 2019; Wan et al., 2017; Wang et al., 2019). This happened despite the lack of policy regulations for non-Bt cotton refuges, due to refugia being sown inadvertently in noteworthy quantities (Tabashnik and Carrière, 2019; Wan et al., 2017; Wang et al., 2019). In particular, small-scale farmers cultivated second-generation (F_2)[3] cotton seeds produced from Bt and non-Bt cotton plants and sold by Chinese private seed corporations at prices 35 % lower than their F_1 counterparts[4] for economic reasons (Tabashnik and Carrière, 2019; Wan et al., 2017; Wang et al., 2019). This seed mixture resulted in a non-Bt proportion of the area under cotton in China from 12 % in 2009 to approximately 25 %–27 % in the years from 2011 to 2015 (Wan et al., 2017, p. 5414; Wang et al., 2019, p. 528; Tabashnik and Carrière, 2019, p. 2518; Mohan, 2020, p. 1748). As a result, the previously observed increase in PBW resistance declined again due to farmers' planting of F_2 seeds (Tabashnik and Carrière, 2019; Wan et al., 2017; Wang et al., 2019) (Fig. 2).

[3]Hybrid seed production aims to produce seeds that express a higher vigor (e.g., higher yield or size) than regularly bred seeds due to the "heterosis effect" of hybrid breeding techniques. This effect is achieved by crossing previously inbred parental lines which then generate a filial generation (F_1) which expresses the desired properties. The F_2 generation is the filial generation emerging from the F_1 generation. As the relevant genome decays in the following generations, their properties are considered unreliable.

[4]While the issue of seed purity is also present in India and lively discussed in the literature in the context of stealth and spurious seeds (Herring, 2007, 2021; Ramaswami et al., 2012; Stone et al., 2014), the case differs from the second-generation (F_2) cotton seeds in China. As the biological specifics are out of the scope of this paper, we refer to Wan et al. (2017), Singh et al. (2016), and Bakhsh et al. (2012) for more detail.

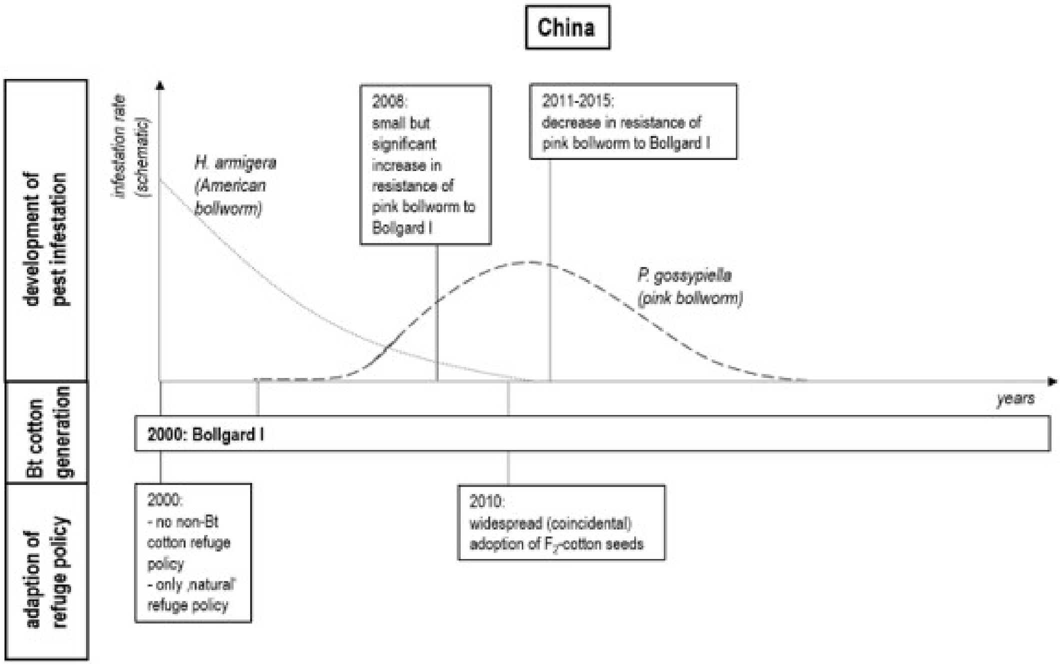

Figure 2. Refuge policies and pest development in China.

3.4 The Indian refuge policy

While India is currently the world's leading cotton producer, Indian cotton production is mostly in the hands of smallholders with average farm sizes of 3.7 acres (approx. 1.5 ha), characterized by a low degree of mechanization (e.g., manual weeding and harvest), and yields below the world average of 1157 kg ha^{-1} (seed cotton) in 2019 (FAO, 2021; ISAAA, 2017; Kumar et al., 2021; Stone, 2007; USDA, 2020a). Indian farmers do not benefit from protection schemes such as crop insurance (Kumbamu, 2006). Irrigation systems are not ubiquitous, as only the northern states of cotton production, accounting for 35 % of cotton production, are predominantly irrigated, while central and southern cotton-producing states are predominantly rainfed (Choudhary and Gaur, 2015). While seed producers in other Bt cotton-growing countries usually revert to non-hybrid cotton seed varieties for the implementation of Bt traits, Indian Bt cotton is almost exclusively induced into hybrids (Tabashnik and Carrière, 2019).

The first generation of Bt cotton technology (Bollgard I) was introduced to the country in 2002 and contained a single gene (Cry1Ac) of the Bt bacterium. Intended to produce further pest control through an additively inserted gene, its double gene (Cry1Ac and Cry2Ab) successor (Bollgard II) was introduced in 2006, and today, an estimated 95 % of the Indian cotton area is cropped with Bollgard II hybrids (ISAAA, 2017). Among the three leading cotton-producing countries, India, China, and the USA, India is the only country that has not (yet) authorized a herbicide-tolerant genetically engineered (GE) cotton variant (ISAAA, 2017). The third Bollgard generation (Bollgard III), for example, has not (yet) been commercialized in India, as it differs from the first two Bt cotton generations in that it includes not only an insect resistance trait but also an induced herbicide tolerance. While the other two countries have authorized other GE herbicide-tolerant cotton variants, this genetic modification hitherto remains unauthorized by the Genetic Engineering Approval Committee (GEAC)[5] (ISAAA, 2017). However, illegal cultivation of the Bollgard III crop has recently led to a major controversy among cotton farmers and authorities in the country (ISAAA, 2017).

In India, the refuge policy measure was introduced parallel to the Bt cotton technology itself when the GEAC under the Ministry of Environment, Forest and Climate Change (MoEFCC) concurrently stipulated refuge specifications for the crop (Choudhary et al., 2014; Kranthi et al., 2017; Mohan, 2018, 2020; Shukla et al., 2018). In contrast to the original policy decreed in the USA, which required a refuge share of 25 %, these adapted refuge policy specifications advised that 20 % of the total Bt cotton area of a given acreage be cropped with non-Bt cotton hybrids or "a minimum of five border rows of conventional (non-*Bt*) cotton hybrid of the corresponding *Bt*-hybrid" be planted for each field, whichever is higher (Kranthi et al., 2017, p. 1992; see also Mohan, 2018; Kumar et al., 2021). As these guidelines came into force, Bt seed producers were directed to provide a separate pack-

[5]Since 2010 it has been known as the Genetic Engineering Appraisal Committee.

age of non-Bt seeds (120 g) with every package of Bt seeds (450 g) (Fig. 3) (Mohan, 2020; Kranthi et al., 2017).

While this translation of the policy measures had hence remained similar to its original version initially mandated by US authorities, these stipulations were subsequently modified by the GEAC and adapted to the Indian context (Mohan, 2020). Mirroring the lack of practical feasibility for seed producers and users alike, due to the great expense of retrieving non-Bt original cultivars from inbred lines of now popular forward-breeding techniques[6] (Mohan, 2018), in 2006, the GEAC eased the guidelines regarding refugial non-Bt cotton crops so that the required refuge crop characteristics were extended from the isogenic Bt hybrid, i.e., the exact counterpart of the respective hybrid apart from the Bt trait, to any popular non-Bt hybrids that were of similar duration and fiber quality (GEAC, 2006). Then, in 2008, the committee diagnosed the "need to suggest [an] alternate and practical IRM strategy suitable for the agricultural practices in the region" due to a low compliance level and thereby stressed the necessity of localized policy adaptations (GEAC, 2008). Interestingly, in regard to policy mobility and lesson drawing, the authority directly hinted at the option of taking the successful "experience of [the] US and China [. . .] into consideration while formulating the [revised] IRM strategy" (GEAC, 2008). In the following years, the committee authorized several alterations to the policy. In 2009, the committee approved the cultivation of pigeon peas as a refuge crop around Bt cotton fields, arguing that this emphasizes traditional agricultural practices in the region (GEAC, 2009). These noncotton refugia were found to be effective against the major cotton pest prior to the introduction of Bt cotton in India, the polyphagous American bollworm (*Helicoverpa armigera*). However, similar benefits could not be found for the case of the monophagous pink bollworm (*Pectinophora gossypiella*) (Mohan, 2018; Sarate et al., 2012).

Multiple further policy changes were put into practice in 2011. The GEAC permitted the planting of block refuge crops as a single patch instead of prescribing an enclosing refugial area, aiming to encourage policy implementation for smaller farms (GEAC, 2011). This again underlines the local adaptation of policies, as Indian farmers' landholding sizes are substantially smaller than those of US cotton farmers. Furthermore, in light of the challenges associated with forward breeding, the use of non-Bt cotton varieties with similar fiber properties was allowed in addition to non-Bt hybrid seeds to facilitate the production of an adequate quantity of non-Bt seeds for seed producers (GEAC, 2011, p. 3; Mohan, 2018). The same year, the committee approved the downsizing of the required refuge percentage from the initial 20 % to a mere 5 %, arguing that now Bollgard II containing two genes (Cry1AC and Cry2Ab) was widely diffused with improved efficacy (GEAC, 2011). Moreover, Indian authorities referred to other Bt cotton-producing countries, where the refuge size had also been reduced, or even abolished, as was the case in the USA (GEAC, 2011). However, this line of reasoning ignores the fact that the conditions in these countries were entirely different (Fig. 4).

Thus, while the USA and China were able to prevent the Bt resistance of pink bollworm populations or even eradicate the pest altogether, in India, pink bollworms are now considered resistant to both authorized Bt cotton generations (Bollgard I and II) (Wan et al., 2017; Tabashnik et al., 2012, 2021; Tabashnik and Carrière, 2019; Mohan, 2018, 2020). In response, the Indian refuge policy has recently undergone another transformation. In 2016, the implementation of the "refuge-in-bag" (RIB) policy[7] was endorsed and executed in 2020 (Mohan and Sadananda, 2019; Kumar et al., 2021). In contrast to the "structured refuge" policy with RIB, the mandated 5 % of non-Bt cotton seeds are integrated in and blended with the Bt seed package (475 g) (Fig. 5) (Kumar et al., 2021; Kranthi et al., 2017). Hence, by withholding farmers from the choice of (refraining from) planting a refuge, this method is referred to as "compliance-assured" (Mohan, 2020; Kranthi et al., 2017). The fact that Indian authorities resort to this technique of enforcing the refuge policy against the policy recipients' consent demonstrates again that the farmer is regarded as the decisive obstructing link in the chain of refuge policy implementation.

3.5 Mistranslations at the national administrative level

Our analysis of the refuge policy assemblage at the national administrative level shows that India's IRM strategy differs substantially from the successful strategy pursued by the USA and the coincidentally effective implementation in China. Whereas in the USA, a multitactical strategy was applied, which first followed the strict implementation of refuge crop plantings and then shifted to the dissemination of sterile moths with the concomitant renouncing of refuge crops, Indian authorities relied entirely on refugia as the only IRM strategy while at the same time diluting this monotactical strategy through unilateral policy alterations (Tabashnik et al., 2021; Mohan, 2017; USDA, 2018). We interpret these policy-diluting alterations as mistranslations. First, they left out entire parts of the policy measures they intended to copy (e.g., the dissemination of sterile moths); second, they adopted other parts of foreign policy alteration while neglecting relevant counterparts (e.g., they reduced the required refuge percentage without complementing the multitactical aspect of the sterile moth releases);

[6] As opposed to backcrossing breeding techniques which revert to the original cultivar for each individual seed breeding, forward-breeding techniques use the most promising cultivar of each seed generation as the recurrent parent (Mohan, 2018). Forward-breeding techniques thus complicate the process of retrieving original cultivars, such as non-Bt cultivars from parental breeding lines.

[7] This is sometimes also referred to as "built in refuge" (BIR) (Kumar et al., 2021).

(a) (b)

Figure 3. **(a, b)** Seed bag with structured non-Bt refuge seeds (photo: Katharina Najork, taken in 2019).

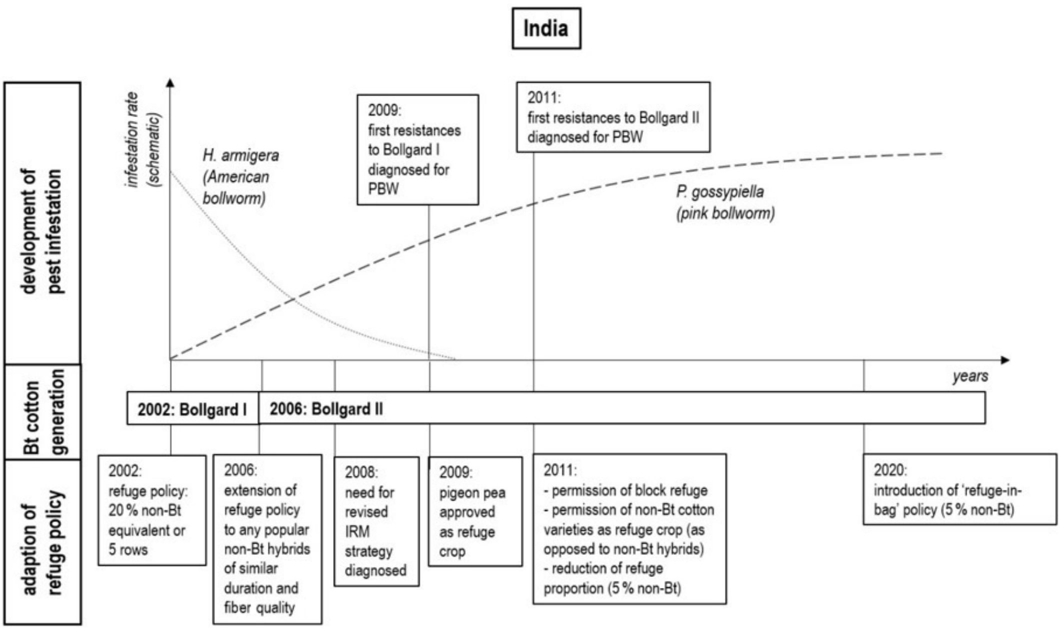

Figure 4. Refuge policies and pest development in India.

and last, they defectively regulated existing policies (e.g., allowing noncotton refuges as an alternative to non-Bt cotton refuges despite the prevalence of monophagous insects). These contrary developments in bollworm populations underline that policy modifications are the result of a complex meshwork (Peck and Theodore, 2010; Cochrane and Ward, 2012). At the same time, it needs to be acknowledged that the USA portrays a successful example of policy implementation, which involves an immense financial and administrative effort and requires resources that might not be available to other countries. This hints at asymmetrical power relations and the power-laden constitution of policy translation processes (Peck and Theodore, 2010; Peck, 2011; Stone, 2012; McCann and Ward, 2013), as pressures of a globalized market can enforce the implementation of progressive technologies in countries that fail to uphold durability in technology due to economic limitations.

At the same time, India did not benefit by chance due to random mutation of the policy's implementation, unlike China, where the coincidentally active role of farmers as well as Chinese seed producers helped to successfully suppress the target pest. In the case of China, it was thus an unintentional mutation of the policy that led to a successful translation by mere chance (Tabashnik and Carrière, 2019; Wan et al., 2017; Wang et al., 2019). This shows that policies are embedded in messy realities, and they morph and mutate (Peck and Theodore, 2010; Peck, 2011; Stone, 2012). Thus, special attention should be given to the notions of randomness and arbitrariness when considering policy assemblages.

Figure 5. RIB seed package (photo: Katharina Najork, taken in 2019).

To solve the problem of an unsuccessful refuge policy translation for Indian authorities, we see the responsible Indian state authorities in compulsion to act and not, as is often argued, the Bt cotton farmer. While relying on China's successful policy implementation would mean blindly trusting a coincidental policy mutation, we suggest US policy as a potential solution in the form of a state-run multitactical program that includes the release of sterile moths on the one hand and a concomitant renunciation of refuge crop implementation on the other hand. With that, we underline the necessity for Indian authorities to proactively tackle the policy mistranslations that have hitherto occurred.

4 Following the policy to farmers in Telangana

While the above-outlined adaptations and (mis)translations of IRM strategies depict an international administrative comparison, we now move on to the local level and to the perspectives of farmers. For this purpose, we revert to a mixed method approach, as we present results from a representative survey ($n = 457$) conducted in 2019 in Telangana's major cotton-producing districts Adilabad, Warangal, and Nalgonda (Fig. 6). We later underpin our quantitative findings with previously gathered qualitative data. These data were gathered in the district of Karimnagar in Telangana in August and September 2018, where we conducted 42 problem-centered interviews in three different locales.[8] The interview partners were mostly Bt cotton farmers, but this group also included other relevant actors in the nexus of Bt cotton production.[9]

The districts vary in their geographical characteristics: Adilabad belongs to the northern Telangana zone of agricultural production; Warangal is considered part of the central zone; and Nalgonda belongs to the southern Telangana zone. As such, the precipitation rates of the districts vary. Adilabad ranks highest in this regard with a rate of 1460 mm in 2018–2019; Warangal follows with a precipitation rate of 812 mm in 2018–2019; and Nalgonda is the driest of the three districts with 553 mm in 2018–2019. For all three districts, the majority of the precipitation occurs during the monsoon (*kharif*) season, i.e., the season during which cotton is grown (from its sowing in June to the harvest from November to January). Considering the population density of the three districts, Adilabad ranks lowest (170 persons per square kilometer); Nalgonda ranks second (245 persons/km^2); and Warangal ranks highest (273 persons per square kilometer) (INDIASTAT, 2021a, b, c). Warangal's high population density mirrors the supra-regional significance of the district's capital, the city of Warangal.

Within these three districts, we randomly selected five villages per district within determined *mandals*[10] in the range of 1000 to 6000 inhabitants and calculated representative sample sizes according to the Indian census data village population size (Government of India, 2011)[11]. Interview partners were found via random walks and interviewed by six Telugu-speaking surveyors. Due to our research question, we specifically focused on cotton-growing households. The questionnaire included open-ended and closed questions and Likert-scale, single-choice, and multiple-choice questions.

4.1 General description of the survey sample

The demographics (age) and levels of education of the 457 interviewed household heads (HHs) are depicted in Fig. 7. While a majority of the sample (40 % or 183 respondents) had not received any education, all categories of education were represented. The distribution of educational levels differed among the three districts (Warangal: 29 % with no education; Nalgonda 48 %; Adilabad: 49 %).

[8] We focus on quantitative data and the conducted cluster analysis for our argumentation and revert to qualitative data only to provide further context for this. Please see Najork et al. (2021) for a detailed description of the methodology and further empirical insights of the previous qualitative study.

[9] Refer to the Supplement for a detailed overview of the interviews.

[10] A *mandal* is the administrative division subordinate to a district.

[11] Refer to the Supplement for a detailed overview of the sample.

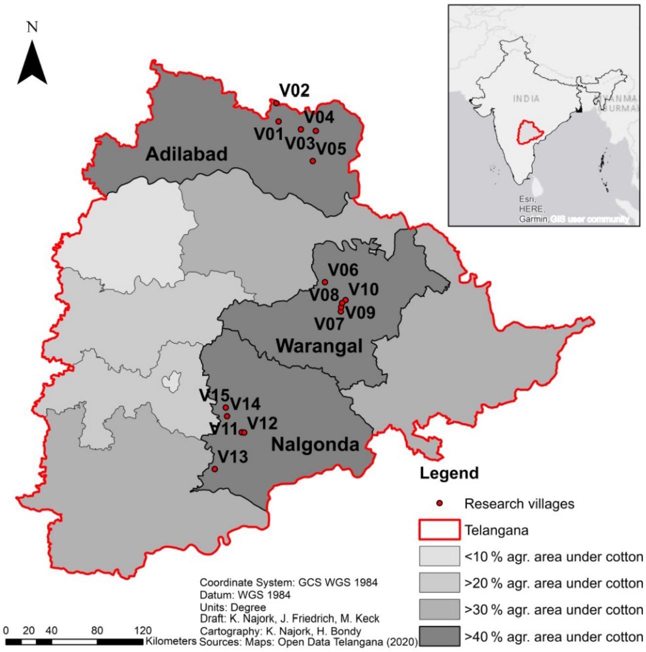

Figure 6. Research area in Telangana (Government of Telangana, 2017).

The mean farmland size of the interviewed HHs amounted to 5.5 acres (approx. 2.2 ha), with a minimum of 0.5 acres (approx. 0.2 ha) and a maximum of 50 acres (approx. 20.2 ha; $n = 456$). Of these farms, an average of 4.1 acres (approx. 1.7 ha) were owned, accounting for an average share of owned farmland of 83 %, while an average of 17 % was leased ($n = 456$). Warangal deviated from the other two districts, with 3.4 acres (approx. 1.4 ha) owned (Adilabad: 4.9 acres, approx. 2.0 ha; Nalgonda: 4.4 acres, approx. 1.8 ha). However, the share of owned farmland per household was largest in Warangal, at 88 % (Adilabad: 74 %; Nalgonda: 81 %). The share of owned farmland varied between 0 % and 100 %, indicating large disparities between individual farms. Cotton cultivation took place on 4.0 acres (approx. 1.6 ha) on average, which accounted for 73 % of the total cultivated farmland ($n = 453$). The share of land cultivated under cotton was 56 % in Warangal but amounted to 77 % in Adilabad and 89 % in Nalgonda. On an individual scale, the share of farmland under cotton varied between 6 % and 100 %, resulting in an overall median of 75 %.

The vast majority of interviewed HHs (86 %) stated that they had grown Bt cotton, and they had been growing Bt cotton for an average of 8 years ($n = 392$). The remaining 14 % were unaware of their seed varieties (one HH answered that they were growing non-Bt cotton); 1 % of interviewed HHs stated that they were growing the herbicide-tolerant third-generation variant (Bollgard III), which is illegal ($n = 390$). Examples of the seed brands used ranged from Nuziveedu (for example, Bhakti and Mallika) and Rasi (659) to Aditya (Moksha). Almost all the interviewed farmers (97 %) declared purchasing their seeds from local seed shops ($n = 457$). In their seed choice, farmers were mostly influenced by fellow farmers (49 %) and shop owners (40 %) ($n = 457$). However, the influences varied noticeably at the district level: while in Adilabad, more farmers were oriented toward input shop owners (45 %) and less toward fellow farmers (36 %), the allocation in Warangal was the opposite (fellow farmers: 54 %, input shop owners: 35 %; for Nalgonda, fellow farmers: 49 %, input shop owners: 43 %). No farmer responded to be influenced by the governmental agricultural extension services, Krishi Vigyan Kendra (KVK). The distribution channels chosen for the sale of cotton produce were diverse overall (commission agent: 40 %, market auction: 28 %, cotton miller 18 %, Cotton Corporation of India (CCI): 12 %, contract: 2 %) ($n = 457$) but varied more at the district level (for Nalgonda, commission agent: 64 %; for Warangal, market auction: 54 %; for Adilabad, cotton miller: 36 %, commission agent: 23 %, CCI: 21 %, market auction: 20 %).

4.2 Refuge crop IRM strategy

The subject matter of the refuge crop IRM strategy was examined on two levels, one concerning farmers' theoretical knowledge about the policy and the second concerning its tangible realization in farmers' Bt cotton fields. Regarding theoretical knowledge, 66 % of the respondents answered that they had been informed about the Indian refuge policy, and 33 % claimed to have not been informed ($n = 457$). This variable showed moderate correlations with both the educational status of the respondents ($\varphi = 0.246$, $p = 0.000$, $n = 452$), as those with a higher educational status more often answered that they had been informed than others, and their share of farmland under cotton cultivation ($\varphi = 0.263$, $p = 0.000$, $n = 452$), as particularly those farmers with a share of farmland under cotton of 75 % or higher more often answered that they had not been informed of the policy. Warangal clearly stands out compared to the other two districts, with 88 % of informed respondents (Adilabad: 48 %; Nalgonda: 52 %) ($\varphi = 0.391$, $p = 0.000$, $n = 452$).

The majority of those farmers who answered that they had been informed about the policy said that they had learned about the policy from the shopkeeper where they had bought their seed (72 %) ($n = 302$). Additionally, 10 % of the respondents stated that they had been informed by fellow farmers or seed companies, and 8 % stated that they had been informed via agricultural officers, advertisements, information on the seed package, or other sources. These figures varied slightly at the district level, exemplified by the percentage of farmers who were informed via a shopkeeper, with 80 % in Nalgonda and 64 % in Adilabad (Warangal: 71 %).

Data relating to farmers' knowledge about the purpose of the attached non-Bt seed package were also collected ($n = 457$). Farmers explained the purpose from their per-

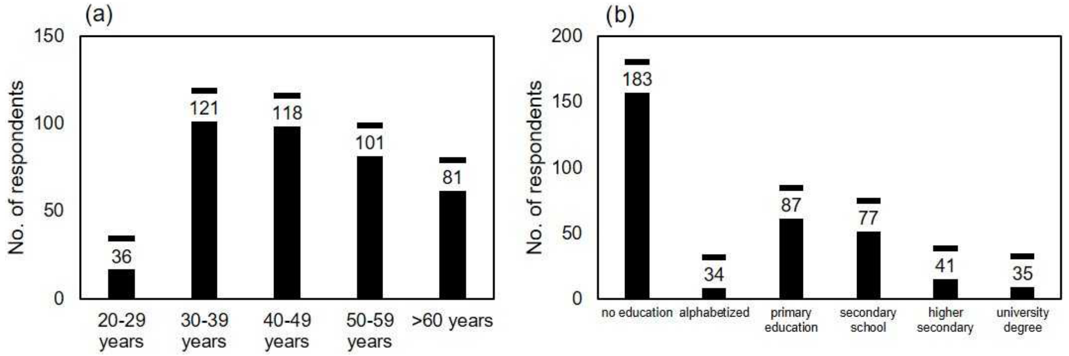

Figure 7. **(a)** Demographics (age) of household heads ($n = 457$). **(b)** Highest education of household heads ($n = 457$).

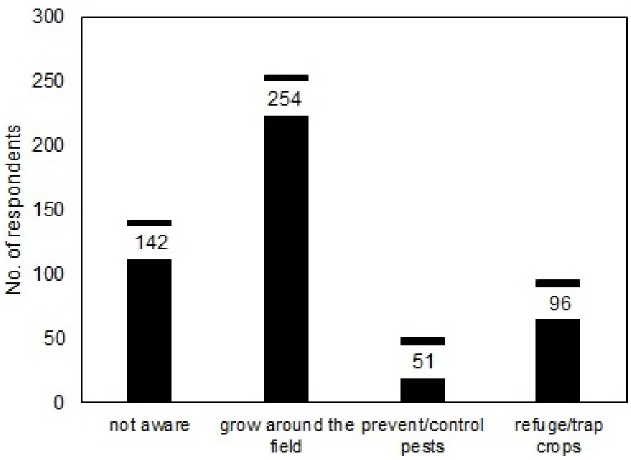

Figure 8. Suggested purpose of the attached seed package ($n = 543$).

spective before their answers were inductively categorized. The majority of farmers responded that the crops were to be planted around the Bt cotton field (47 %), and 18 % were able to give the correct term of the measure ("refuge" or "trap crops"), while only 9 % replied that their purpose was to prevent pest infestation; 26 % claimed to be unaware of the purpose of the attached seed package (Fig. 8).

Again, Warangal stands out in a comparison at the district level, as 47 % answered that the seeds were to be planted around the Bt cotton field, while in Adilabad and Nalgonda, the majority claimed not to be aware of the purpose (47 %; 49 %). The concept of mixed RIB was known by 47 %, while 53 % were unaware of the new measure ($n = 457$). The concept was noticeably less known in Adilabad (38 %) and Nalgonda (25 %), but in Warangal, the majority of farmers (72 %) knew about the new method[12] ($\varphi = 0.423$, $p = 0.000$, $n = 401$).

[12] At the time of this research in September 2019, the measure of mixed refuge crops was not yet compulsory.

Regarding the actual implementation of the IRM strategy, we found variation among all three districts ($n = 453$). In Nalgonda, only 27 % stated that they actually grow a refuge; in Warangal, 59 % said that they do so (Adilabad: 43 %) ($\varphi = 0.284$, $p = 0.000$, $n = 453$). The actual compliance correlated moderately with the diversification of cultivated farmland ($\varphi = 0.226$, $p = 0.000$, $n = 453$) and, in turn, with the share of farmland under cotton cultivation, as those respondents with 75 % or more of their farmland under cotton answered more often that they are not growing a refuge ($\varphi = 0.205$, $p = 0.000$, $n = 453$). Of those farmers who claimed to grow a refuge, 93 % stated that they were growing the required non-Bt crops around their field as opposed to a block refuge on the sides of the field (5 %) or the new mixed refuge (2 %).

Altogether, 56 % of farmers declared that they did not comply with the refuge policy. Of these, 93 % stated that they had never done so in general ($n = 242$). Of those farmers who answered that they did not comply, 45 % stated that they did not follow the instructions due to "low yields" or because the non-Bt cotton refuge crop "does not grow"; 26 % claimed that the measure was "of no use" or even "attracts pests"; and 2 % stated that they did not grow the refuge because "no one else grows it". An additional 27 % stated that they were not aware of the policy ($n = 244$) (Fig. 9). These particulars varied strongly on a district level (not aware, Warangal: 13 %; Adilabad: 26 %; Nalgonda: 37 %).

4.3 Cluster analysis

We built on these bivariate analyses for the choice of the most relevant variables for the multivariate cluster analysis ($n = 438$) (Fig. 10 (i) preprocessing). Based on this groundwork, we conducted a two-step cluster analysis aimed at identifying different farmer types in the Telangana cotton farming community. While the cluster analysis involved the study of several possible group constellations featuring varying numbers (2–5), we chose the composition with the highest possible silhouette measure (Fig. 10 (ii) cluster analysis). Variables that negatively influenced the silhouette measure

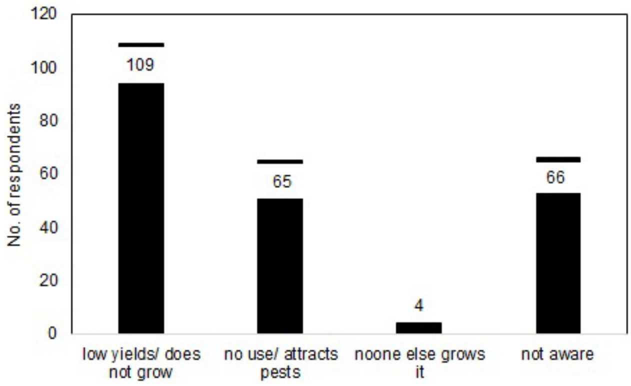

Figure 9. Reasons for noncompliance ($n = 244$).

were externalized from the cluster analysis itself as evaluation variables. As such, they had no direct influence on the cluster composition but were still examined for correlations. We decided to present a model with two distinguished groups of Bt cotton farmers due to its attributed "good" cluster quality (average silhouette measure: 0.5). This model comprises (a) "entrepreneurial" ($n = 139$) and (b) "diversified" ($n = 299$) farmers. The variables with the highest predictor importance that mostly influenced the categorization of the two clustered groups were those related to farmers' information and knowledge about Bt cotton refuge crops and their purpose (Table 1). The resultant two cluster groups were then again tested for correlations with the original key variables (Fig. 10 (iii) postprocessing).

After processing the cluster analysis, the two resultant groups were again tested for correlations with the key variables and evaluation variables. Significant correlation values that in turn confirmed the results of the previously conducted cluster analysis were found for the variables listed below (Table 2).[13]

4.3.1 The entrepreneurial group

The first group modeled by means of the analysis accounts for 31.7 % ($n = 139$) of the sample (55 % from Nalgonda; 29 % from Adilabad; 16 % from Warangal). In comparison with the second group of farmers, this group is characterized by a poorer layout of socioeconomic resources: only 17 % claimed to have a secondary-school certificate or higher, and 57 % indicated that they had not received any official education. Their total acreage amounted to $\overline{x} = 5.03$ acres (approx. 2.0 ha), of which $\overline{x} = 4.02$ acres (approx. 1.6 ha) were owned.

The two groups differ most strikingly in regard to their knowledge and implementation of the refuge crop policy (Tables 1, 2). This group is defined by the large number of farmers who were not informed about the IRM strategy (100 %). Congruously, 90 % of the farmers of this group were unaware of the purpose of the attached non-Bt cotton seed package. This was reflected in the high percentage that answered that they did not grow the required refuge (99 %). Of the respondents who did not comply with the measure, 48 % answered that while not being explicitly informed about the measure, they were aware of it but still did not adhere to it, as its implementation was financially not profitable (unaware: 46 %).

The agricultural production of this group is characterized by a specified cotton cultivation, as 81 % of their average field area is devoted to cotton; the median of proportional farmland under cotton amounts to 98 %; hence, half of the respondents are almost exclusive cotton growers. Due to their pronounced focus on monocropping, which in the production of cotton implies a comparatively high risk (cf. Gaurav and Mishra, 2012; Gutierrez et al., 2015), combined with their less detailed knowledge regarding agrarian background information of the crop, we regard this group of farmers as oriented toward short-term profit maximization and refer to them as entrepreneurial producers.

4.3.2 The diversified group

This cluster group amounts to 68.3 % ($n = 299$) of all interviewed farmers (56 % from Warangal; 28 % from Nalgonda; 16 % from Adilabad). This group is overall better advantaged in terms of socioeconomic resources: here, farmers are more educated than the first group, as only 33 % claimed that they did not receive any official education, but 39 % claimed to have achieved an educational level of secondary-school certificate or higher. Additionally, the average total farmland size of this group was slightly higher and amounted to $\overline{x} = 5.72$ acres (approx. 1.7 ha), of which $\overline{x} = 4.09$ acres (approx. 2.3 ha) were owned.

In sharp contrast to the first group, 99 % of farmers in this group answered that they had been informed about the refuge policy. Of these, 79 % received information from their local seed seller, and 95 % correctly described the strategy's purpose as "grow around the Bt cotton field" (50 %) and "pest control" (16 %) or named it accurately as "refuge/trap crops" (29 %). Congruously, a higher compliance was found, as only 35 % of farmers did not grow the refuge. However, 33 % of informed farmers argued that they did not comply because this was financially unprofitable.

Another striking difference from the first group was found in the agricultural production of this group, as it was noticeably more diversified (average of farmland under cotton: 72 %; median 67 %). Based on this group's diversified cropping patterns and distinct agrarian knowledge, we understand this farmer type to be seeking low-risk and long-term secure production and refer to them as diversified.

[13] Those key and evaluation variables that are not listed here either showed no significant correlation values or could not be considered due to low frequency levels in individual cells.

Table 1. List of key and evaluation variables used in the cluster analysis with summarizing statistics (silhouette measure of cohesion and separation: 0.5; ratio of sizes (largest cluster to smallest cluster): 2.15).

No.	Key variable	Short name	Scale	Predictor importance
1	Informed about refuge crops	REFC_INF_YN	Categorical	1.0
2	Purpose of refuge crops	REFC_PUR	Categorical	0.74
3	Currently growing refuge crops	REFC_YN	Categorical	0.37
4	Level of education	EDU	Categorical	0.06
5	Percent of cotton in agricultural area	COTTON%	Metric	0.01
6	Total agricultural area [acres]	FARMLAND	Metric	0.01
7	Owned agricultural area [acres]	FARM_OWN	Metric	0.01
No.	Evaluation variable	Short name	Scale	Predictor importance
1	District affiliation	DISTRICTS	Categorical	0.14
2	Reason for not growing refuge crops	REFC_NO	Categorical	0.49
3	Degree of severity of lack of irrigation	IRRIG_SE	Categorical	0.02
4	Degree of severity of drought	DROUG_SE	Categorical	0.00
5	Degree of severity of pink bollworm infestation	PBW_SE	Categorical	0.00
6	Informed about refuge crops by seed shop keeper	INF_SHOPK	Categorical	0.98
7	Distribution of cotton produce via open auction	DISTRIBUTION_AUCTION	Categorical	0.10
8	Distribution of cotton produce via commission agent	DISTRIBUTION_CAGENT	Categorical	0.05

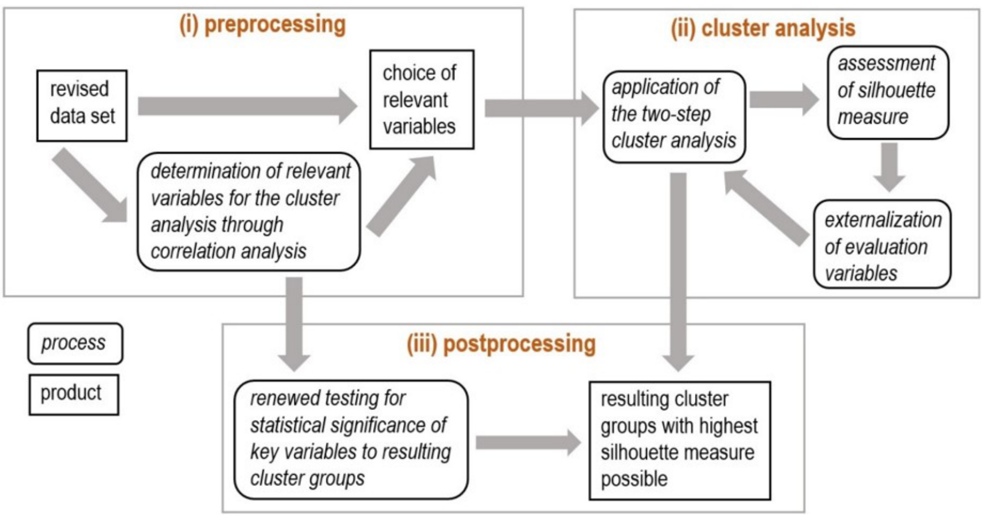

Figure 10. Processing the two-step cluster analysis.

5 Discussion: mistranslations at the local level

Given our aim to deconstruct the prevalent narrative that blames farmers' noncompliance for evolved resistances in Indian pink bollworm populations while neglecting responsibilities of the relevant state authorities, we now turn to the local site of Indian Bt cotton production to formulate a critical reading of the current situation. For this endeavor, we interlace our findings with policy assemblages and moral economic considerations.

The moral economy grasps microeconomic practices in situ, assesses the justification and fairness of economic relations and practices in specific localities, and analyzes economic matters on site from a "moral point of view" (Sayer, 2018, p. 4; see also Carrier, 2018; Palomera and Vetta, 2016; Sayer, 2000). While the concept of moral economy dates back to the 18th century, the term was introduced by the historian Edward Palmer Thompson with his 1971 article "The moral economy of the English crowd in the eighteenth century". With this essay, Thompson addressed the agency of "the crowd" by thematizing food riots of the urban working population in 18th-century England (Edelman, 2005, 2012; Götz, 2015). Later, Scott (1976, quoted from Palomera and Vetta, 2016) related the concept to rural contexts by linking it to peasant studies with his article "The moral economy of the peasant", in which he discussed examples of collective ac-

Table 2. Postprocessing correlations.

Analyzed variable	n	Pearson χ^2 (p)	Likelihood ratio (p)	Cramér's V	$V_{sig.}$ (p)
REFC_INF_YN	438	0.000	0.000	0.984	0.000
REFC_PUR	438	0.000	0.000	0.859	0.000
REFC_YN	438	0.000	0.000	0.594	0.000
EDU	438	0.000	0.000	0.273	0.000
DISTRICTS	438	0.000	0.000	0.250	0.000
REFC_NO	438	0.000	0.000	0.238	0.000
DISTRIBUTION_AUCTION	438	0.000	0.000	0.294	0.000
DISTRIBUTION_CAGENT	438	0.000	0.000	0.202	0.000
Analyzed variable	**n**	**Pearson χ^2 (p)**	**Likelihood ratio (p)**	**Spearman**	**$V_{sig.}$ (p)**
COTTON %	438	0.000	0.000	−0.219	0.000

tion in early-20th-century Southeast Asian peasant rebellions (Scott, 1976, quoted from Palomera and Vetta, 2016). In doing so, he related the micro setting of peasants' everyday life to superordinate structural changes and exposed the entanglements between them, e.g., between farmers' livelihoods, the emergence of colonial states, and the expansion of free trade (Palomera and Vetta, 2016). He particularly addressed peasants' subsistence economies and argued that they were carried out by "risk-averse social agents" with a "safety-first principle" as their guiding principle. This stood in contrast to the neoclassical *Homo economicus* or "the would-be Schumpeterian entrepreneur" (Scott, 1976, p. 4, quoted from Palomera and Vetta, 2016, p. 417).

In the case presented here, questions regarding moral economic and refuge policy interlaces concern the role of middlemen (cf. Kumbamu, 2006). In line with Kumbamu (2006), our findings confirm that farmers often fall back on middlemen or retailers for advice due to an inadequate influence of extension services (e.g., KVK). Often farmers rely on the same person for inputs (seeds, pesticides, fertilizer) in the beginning of a season and cash or loans at the end of a (failed) season (Village01–Interview09, V01–I09; cf. Najork et al., 2021). As these intermediaries in turn count on farmers' ability to repay their debt, middlemen have their own short-term economic interests in mind when advising farmers. Unable to refer to the formal bank system for loans (Najork et al., 2021, 2022), resource-poor farmers are particularly dependent on these sources. In this regard, our findings expose geographical congruities, as farmers in Warangal are economically better off on average while less often reverting to commission agents or cotton millers for the distribution of their produce and instead prefer market auctions as their sales channel.

Another moral economic issue that our results expose concerns collaborative long-term consequences in the form of the classical game theoretic prisoner's dilemma (Diekmann, 2013). As the testimony of one farmer underscores, the noncompliance is not necessarily due to ignorance: "[S]ince we are not growing a refuge crop, the insects and worms are directly affecting the Bt [crops], and they are becoming resistant to the technology. [I]f everyone start[ed] growing a refuge crop, it would be very useful" (V02–I01). However, despite being aware of the policy, some interviewees still purported that it would simply make no sense to follow the refuge instructions because no one else is growing a refuge (V02–I07; V03–I08). Thus, if they did adhere to the instructions, they would end up with lower earnings compared to those who did not pursue as instructed: "[I]f the neighbor does not grow it, [I] will also not grow it. If I grow it and he doesn't grow it, then he will get more profit than me" (V02–I01). This rationale aligns with the sociological allegory of the prisoner's dilemma, according to which the behavior of individuals can lead to devastating results for the collective (Diekmann, 2013). In our case, the entrepreneurial rationale led individual farmers to refrain from compliance while collectively undermining the longevity of Bt technology. Ironically, it is thus the entrepreneurial way of cultivating Bt cotton that thwarts the technology's longevity, as utilitarian monocropping-oriented producers are contributing the least to sustain the long-term efficacy of the technology.

Recently, however, as Stone and Flachs (2017) outline, increasingly modern and industrialized cotton production has been promoted in India through Indian government policies, the agro-scientific establishment, and favorable market conditions, which has encouraged farmers to turn toward a more entrepreneurial agricultural logic. This mindset of intensifying modernization, incentivized, for example, by climbing support prices of input-heavy cotton, rejects traditional farming practices, as these are regarded as "backward" and instead favors capital- and input-intensive farming practices (e.g., hybrid seeds; increasing water, fertilizer, and insecticide intensity; cash- and monocropping; and nonsubsistence) (Stone and Flachs, 2017; Flachs and Stone, 2018). However, in following such "modern" practices, farmers are more susceptible to external influences in their agricultural decisionmaking (didactic learning), with negative effects on their local knowledge resulting in agricultural deskilling (Stone, 2007; Stone and Flachs, 2017).

We argue that the above-described administrative mistranslations of the Bt cotton refuge policy at the national level in India result from neglecting this new entrepreneurial-farmer subjectivity on part of Indian authorities. We see that certain governmental regulations, e.g., the focus of support prices on input-heavy cotton, incentivize this modern farmer type while paradoxically conceiving farmers in general to be still oriented toward subsistence. The relevant Indian state authorities thus ignore the entrepreneurial-farmer type, aiming at short-term profit maximization through intensified production, which has already been pursued by a large share of Indian cotton farmers. Therefore, we argue that to improve refuge policy translation processes, the responsible state actors cannot merely rely on place-insensitive training programs and educational schemes but need to account for different farmer subjectivities that have emerged in the past decades through the promotion of the logic of entrepreneurial-farming practices.

With this argumentation, we add to the findings of Stone and Flachs (2017), who exposed this transition of cotton farmers from traditional subsistence to modernized entrepreneurialism and provided evidence that this shift is accompanied by deskilling and a loss of agricultural knowledge, in our case related to Bt refuge policies (cf. Flachs, 2019; Flachs and Stone, 2018; Stone, 2007; Stone et al., 2014). As our results of bivariate and multivariate analyses indicate, an entrepreneurial agricultural logic, here in the form of an increasing degree of cotton monocropping, negatively impacts the success of refuge policy translations (Sect. 4.3.1).

We see the major cause for this entrepreneurial monocropping strategy to lay in a lack of resources, which drives farmers toward risk-taking measures in the hope of gaining short-term profits (cf. Najork et al., 2021, 2022; Louis, 2015). Louis (2015) describes this paradox among Telangana cotton farmers, in which the most resource-poor farmers are constrained in their cultivation choice to fluctuating cash crops like Bt cotton, as they simply cannot afford a diversified agricultural production and are thus pushed toward high-risk cotton monocropping systems for short-term economic benefits[14]. In line with Louis (2015), we argue that these fragile asset-related preconditions pressure farmers to refrain from planting refuges (Najork et al., 2021, 2022; Tabashnik et al., 2010). While sustaining the technology in the long run, refuges go along with yield losses and hence "short-term economic sacrifices for growers" (Wan et al., 2017, p. 5413; cf. Frisvold and Reeves, 2008). Consequently, the cultivation of non-Bt cotton refuges is in direct opposition to the instilled entrepreneurial logic aimed at short-term profit maximization (Wan et al., 2017; Frisvold and Reeves, 2008). We thus find the origins of the noncompliance at the local level to lie in moral economic questions of its recipients, as is the case for the entrepreneurial group of farmers with their restricted asset-related preconditions that is altogether noncomplying. The provision of economic incentives by Indian policy-making authorities to policy-complying growers could therefore be a relevant means of achieving local adoption of refuge crops among Indian cotton producers.

This argument aligns with our cluster groups' geographical backgrounds, as the economically advantaged diversified farmers were more often from Warangal, a district that showed both higher averages in owned farmland and a higher degree of agricultural diversification. We therefore argue that here, economically better-off farmers are less constrained in their agricultural production and can afford to aim not only for short-term profit maximization. While the higher average values also apply for the educational level of farmers in Warangal, we do not neglect education as an influential factor. Yet, we want to stress that education is by no means the only influencing factor. As our analysis exposes, the above-described moral economic considerations are of significant relevance and hence must not be neglected when addressing mistranslations in the Indian policy nexus.

However, our findings also reveal noncompliance with the refuge policy for the diversified group. While the majority of this group is informed about and adhering to the policy, again, most noncomplying farmers in this group stated that they would encounter financial disadvantages if they did. We thus found that even parts of the diversified group of cotton farmers have already adopted an entrepreneurial and utilitarian mindset. Consequently, our findings in this regard again underline the significance of moral economic considerations and show that further educating or informing the farming community on the policy does not guarantee a successful translation.

As portrayed by our policy analysis at the local level in connection with moral economic considerations, we found that educational and informational efforts alone cannot counteract the refuge policy mistranslations that have occurred at the national administrative level. Our findings rather show that moral economic issues are key when addressing mistranslations within the Indian refuge policy nexus at the local level. We therefore see the need for economic incentives to be provided by Indian authorities for adhering farmers. Crop insurance or compensation could provide further relief to small-scale farmers and decrease their pressure to adopt short-term economic maximization logics.

[14]This risk-taking behavior among small-scale farmers does not always have a positive outcome, as is shown by alarming numbers of suicides in Warangal and beyond (Gupta, 2017; Stone, 2011; Vasavi, 2009). However, the role of Bt cotton in these farmer suicides remains controversial (Thomas and De Tavernier, 2017; Herring, 2005).

6 Conclusions

In this article we challenged the prevalent narrative that regards farmers as being responsible for the return of pink bollworms in India's cotton fields due to their noncompliance with the Indian IRM strategy. We therefore followed the policy of refuge crops in Bt cotton production from the national administrative to the local farm level and offered a critical analysis of this narrative informed by the perspective of policy assemblages and moral economic considerations.

On the national level, we showed that India's IRM strategy differs substantially from the successful strategies pursued by the USA and China. For the USA, we found the refuge policy to rest on a multitactical strategy that resulted in the successful eradication of the target pest. For China, we found that a coincidental policy mutation led to the successful suppression of the target pest. In India, in contrast, the policy implementation de facto failed: while being oriented toward successful refuge policy approaches, these were never fully realized. Instead, Indian authorities mistranslated the policy by only partially implementing respective measures while easing or entirely renouncing others.

On the local level, we demonstrated that the farming community in Telangana comprises at least two different farmer subjectivities that are partially pursuing an entrepreneurial agricultural logic. Our findings show that farmers who follow high-risk monocropping and are oriented toward short-term profit maximization tend to not comply with the IRM strategy. Ironically, it is thus this entrepreneurial farmer, incentivized through favorable market conditions, e.g., climbing support prices of input-heavy cotton, and yet neglected by relevant Indian authorities, who counteracts the technology most vigorously by undermining its potential long-term effectiveness.

Altogether, the analyses of the national administrative and the local level of the policy translation nexus indicate two possible solutions to conquer farmers' noncompliance with refuge crop policies in India – both urging for a proactive stance of state authorities, not farmers. The policy analysis at the national administrative level exposed a potential solution in the form of a state-run multitactical program that underlines the necessity for Indian authorities to tackle the policy mistranslations that have hitherto occurred on their side by adjusting the unilateral policy alterations they have conducted throughout the policy's adaptation. Additionally, the policy analysis at the local level revealed the relevance of moral economic considerations and speaks for economic incentives to be provided for adhering farmers and for the introduction of crop insurance and compensation payments in the case of harvest failures.

To date, the responsibilities of Indian authorities have been neglected, and instead, Bt cotton farmers have remained the single entity expected to shoulder the measures necessary for securing the technology's long-term efficacy without receiving financial remuneration. The recent refuge-in-bag variant is now coercing farmers to compliance. We therefore conclude that it is now time for the responsible Indian state authorities to do justice regarding their mistranslations in regard to the role of refuge crops in cotton production and not, as it is often argued, Bt cotton farmers.

Data availability. Regarding the availability of data and material, if not indicated otherwise, the results are based on own empirical data.

Supplement. The supplement related to this article is available online at: https://doi.org/10.5194/gh-77-213-2022-supplement.

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Competing interests. The contact author has declared that neither they nor their co-author has any competing interests.

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